PHYTOTOXICOLOGY ASSESSMENT SURVEY IN THE VICINITY OF ICI FOREST PRODUCTS AND DOMTAR, CORNWALL, 1987-1991

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PHYTOTOXICOLOGY ASSESSMENT SURVEY IN THE VICINITY OF ICI FOREST PRODUCTS AND DOMTAR, CORNWALL

1987 TO 1991

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Standards Development Branch

Report cover 1987 - 1991

EXECUTIVE SUMMARY

Results of analysis of maple foliage, moss bags and soil all revealed a pattern of high mercury concentrations around the ICI mercury cell building. Mercury concentrations in maple foliage, moss bags and soil all tended to decrease with increasing distance from the mercury cell building. Mercury concentrations in maple foliage tended to be above the Phytotoxicology "upper limit of normal" guideline within 1 km of the ICI mercury cell building.

Mercury emissions, from ICI, decreased by 74% from 1976 to 1984. 1984 was the year of lowest emissions over the period from 1976 to 1991. From 1984 to 1991 emissions increased by 20%. Nevertheless, within the 1984 to 1991 period, emissions increased up to 1990 yet decreased from 1990 to 1991.

Maple foliage was found to be a good monitor of mercury emissions. Concentrations of mercury in maple foliage were very high around ICI and decreased with distance from ICI. The foliar mercury concentrations close to ICI are potentially phytotoxic. Nevertheless, mean foliar concentrations have tended to decrease in recent years. Foliar mercury concentrations in 1991 were almost the lowest detected since the survey began.

The results of moss bag analysis show a poor relationship between mercury emissions and mercury concentrations in the moss bags. Continuation of this type of monitoring for mercury is not recommended.

Soil mercury concentrations have significantly decreased from 1985 to 1991. This reduction may be attributable to warm summers in the late 1980s but it is not attributable to reductions in emissions of mercury from ICI. Soil mercury concentrations were found to be influenced more by the mercury emissions from ICI the month prior to the soil sampling than the season, May or August, in which the soil sample was collected.

Elevated chloride concentrations in maple foliage, in the vicinity of ICI and Domtar, are probably related to chronic chlorine emissions from Domtar. ICI is likely a periodic source of acute chlorine emissions.

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Phytotoxicology Assessment Survey in the Vicinity of ICI Forest Products and Domtar, Cornwall - 1987 to 1991

1.0 INTRODUCTION

The Phytotoxicology Section has conducted surveys of mercury contamination of vegetation and/or soil in the vicinity of the ICI Forest Products Inc. (ICI) chlor-alkali plant in Cornwall (formerly CIL), regularly since 1976. In 1985 and 1986, subsequent to complaints from nearby residents, the Phytotoxicology Section also conducted surveys to investigate chlorine contamination and injury to vegetation attributed to emissions from Domtar Ltd., which is located due south of ICI. A report describing the results of surveys conducted near ICI/Domtar in 1984, 1985, and 1986 was released in February, 1988 (10).

The Phytotoxicology Section has continued to conduct annual surveys in the vicinity of ICI and Domtar. This report presents the combined results of recent surveys for the period 1987 to 1991.

2.0 METHODS

In mid-August of each of the years 1987 through 1991, duplicate samples of maple foliage were collected from 22 stations in the vicinity of ICI and Domtar and from control locations in the town of Ingleside, which is located 27 km west of the ICI/Domtar complex (Figure 1). These samples were processed in the Phytotoxicology laboratory prior to submission to the MOEE laboratory at 125 Resources Rd. in Rexdale, for mercury, chloride and fluoride analysis.

Duplicate soil samples (0-5 cm) were collected at the foliage sampling locations on 14 May, 1991 and 21 August, 1991. These samples were processed in the Phytotoxicology laboratory prior to submission to the MOEE laboratory for mercury, lead, zinc and cadmium analysis.

Moss bag monitoring has been ongoing for several years and was again conducted in 1987, 1988, and 1989. Bags were exchanged monthly by MOEE and company staff at six stations downwind of ICI, one station upwind as well as at five locations on the roof of the ICI mercury cell room. Moss bag monitoring was terminated in December 1989 after consultation with the MOEE Cornwall district office.

Concentration contour maps were produced from the foliage and soil data using the graphics program "Surfer version 4.0". The contour maps were only produced where there was a difference between the minimum and maximum values of greater than twice the minimum value. These maps are only statistical approximations of the spatial distribution of the different contaminants. The maps are only to be used to provide information on the approximate areas and/or patterns of contamination. They can not be used to determine the actual concentration of a contaminant at a location where samples were not taken.

The contours produced by the program are affected by the spatial distribution of the sampling sites, the accuracy of the positional information for the sampling sites, and the program options used to generate the contours. As the contours are affected by the spatial

distribution of the sampling sites, the accuracy of the contours deteriorates at the edges of the map and in large areas where there are no sampling sites. Contours near the edge of the map should be interpreted with caution. Large areas without sampling sites have been blocked out so no contours were drawn through them.

The program options used in generating the contours remained constant for each map. The options used for the maps in this report are given below.

Grid Interpolation Method: Kriging
Search Method: Normal
Search Radius: full width of map
No. of Nearest Points: 10
Grid Size: 26 x 20
Contour Smoothing: Yes
Tension Factor: 2

The contour interval, minimum contour and maximum contour are given at the bottom of each map. The location of the sampling sites are indicated by an asterisk and station number. The major roads delimiting the sample area are also included.

3.0 RESULTS AND DISCUSSION

3.1 Mercury (Emissions from ICI Forest Products)

3.1.1 Mercury Emissions from the Cell Room

The chlor-alkali process, used at the ICI plant in Cornwall, produces chlorine, caustic soda and hydrogen by electrolysis of a saturated brine solution in the presence of liquid mercury. Theoretically, mercury should not be consumed in this process, however there are inevitable losses in solid and liquid waste as well as to the atmosphere. This report is concerned exclusively with losses to the atmosphere. The emissions data, obtained from ICI, are calculated using the concentrations of mercury in air samples taken 3 times a week using a gold film mercury vapour analyzer, model 411, Arizona Instrument Company Inc. These data do not take into account emissions from retort operations, in which mercury is recovered from solid waste.

Total annual cell room mercury emissions to the atmosphere, as reported by ICI, are given in Table 1. The 1982 through 1986 values have been adjusted upward from those given in previous reports due to the discovery of an error in the computer program used to calculate emissions. Figure 2 shows annual and growing season (May - August) cell room mercury emissions to the atmosphere from 1976 to 1991. Mercury emissions show a 74% decrease from 1976 to 1984, the year of lowest total emissions. However, from 1984 to 1991 there has been a 20% increase in emissions. The May-August emissions accounted for, on average, 45% of the total emissions (Figure 2). Higher emissions in the summer months may be due to the opening of roof vents to improve ventilation and the increased volatility of mercury in warm weather. A stockpile of brine sludge on the property is likely an additional source of mercury, with greater losses of mercury expected over the summer. Covering the stockpile should reduce these emissions.

3.1.2 Mercury in Moss Bags

Tables 2 gives the mercury concentration in moss bags that were exposed for one month periods on the roof of the ICI mercury cell room. The mean monthly concentration from January, 1987 to December, 1989 ranged from 152 to 1296 ug/g dry weight. This concentration range is similar to the range of 282 to 1212 ug/g dry weight reported for monitoring carried out from May, 1984 to December, 1986 (10). The relational factor of moss bag mercury concentrations to mercury emissions (Table 2) varies widely from 18:1 to 348:1. A similar variability, which was attributed to seasonal trends in mercury accumulation, was observed in previous studies by the Phytotoxicology Section of the MOEE (10). Correlations between various climatic variables and mercury accumulation in moss bags determined that temperature gave the best correlation, ie. there was greater accumulation of mercury in cold weather and less in hot weather (10). Seasonal fluctuations of mercury in the LFH horizons in a poplar stand have been documented (5). The decreased soil mercury concentrations in the summer were attributed to the volatilization of mercury, reported to involve a methylation reaction in response to the flush in microbial activity that ensues as the temperature increases. This seasonal pattern is not evident in the current study. July mercury concentrations were high in both 1987 and 1988 whereas February mercury concentrations were relatively low in both years. In these data there is no consistent seasonal pattern of accumulation. Similarly there is no seasonal pattern of mercury accumulation in the data given in Tables 3 to 5. These tables are of the mercury and chloride concentrations in moss bags exposed from February, 1987 to December, 1989 at stations located at various distances from the ICI/Domtar complex. The highest concentrations of mercury were recorded in August in 1987 and 1989 and July in 1988; not in the winter months as would have been expected had accumulation been greatest in cold weather. High moss bag concentrations of mercury in August may reflect a degassing of mercury from the soil. This has been documented in forest environments where large purges of mercury from the soil were recorded in August (5). The soils around the ICI complex, which over the years have accumulated mercury, may be a source of atmospheric mercury.

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The pattern of mercury accumulation in moss bags on the roof of ICI is not closely related to the magnitude of emissions at any point in time. A linear regression and analysis of variance comparing mercury emissions with mercury accumulation in moss bags gives a very poor relationship that is not significant ($p = 0.3195$, see Appendix B). The reason for this poor relationship is not clear, although it does indicate that moss bags are not good monitors of mercury emissions.

Tables 3 to 5 give the mean concentration of mercury and chloride in moss bags at various distances from ICI and Domtar. The mercury accumulation is highest close to ICI and decreases with distance. Chlorine concentrations are also higher around ICI and Domtar and decrease with increasing distance. Accumulation of chloride is noticeably higher in the winter than in the summer. These data indicate a seasonal pattern to the accumulation of chloride, which is repeated for each of the three years.

3.1.3 Mercury in Maple Foliage

Mercury concentrations in unwashed maple foliage are given in Table 6. These samples were collected annually in the vicinity of ICI from August 1976 to August 1991, with the exception of 1988. In all years, the mean mercury concentration in maple foliage was above the Phytotoxicology "upper limit of normal" (ULN) guideline. The mean values, given in

Table 6 and shown graphically in Figure 3, are highly influenced by the foliar concentrations close to ICI, particularly those from stations 1, 2 and 4. Therefore, these data reflect foliar concentrations in the most highly contaminated areas. Median foliar concentrations given in Table 6 are a better measure of the central tendency in these data. Although the median values are lower than the mean values, nevertheless they are generally above the ULN guidelines. Overall, the median foliar mercury concentrations have decreased by 36% from 1976 to 1991. This has not been a steady decrease, but rather a rapid decrease from the mid 1970s to the mid 1980s, except 1982, and a slight increase from the mid 1980 to the early 1990s.

Figure 3 compares the ICI mercury emissions to the atmosphere with concentrations in maple foliage. Visually there is a good relationship between the two, except in 1982. In 1982 there were problems with the retort operation, in which mercury is recovered from the brine sludge, that resulted in releases of mercury to the atmosphere that were not accounted for in the emissions data provided by ICI (10). A regression analysis of the emissions and foliar mercury concentrations (except 1982) gives a squared multiple correlation of 0.56 (Appendix C). This means that approximately 56% of the variation in maple foliage concentrations can be accounted for by the linear prediction from emissions. The analysis of variance indicates that this is a significant relationship. These data support the use of maple foliage as a good monitor of atmospheric mercury contamination.

Contour maps (Figures 4 to 18), consistently show high concentrations of mercury around ICI. This pattern was also evident in the moss bag data and is typically found around chlor-alkali plants (1). The extent of mercury contamination varies from year to year but the zone of "above-normal" mercury levels (>0.3 ug/g) can extend approximately 2700 m downwind (northeast direction) of the mercury cell room. The highest foliar mercury concentration (23 ug/g dry weight) was recorded 360 m NNE of the ICI mercury cell room at Site 2 in 1982 (10). The highest recorded concentration from 1987 to 1991 was 10.3 ug/g dry weight, also recorded at Site 2 (Table 6). The highest mercury levels in tree foliage have generally been detected at Sites 1,2 and 4. Foliar concentrations decrease sharply with increasing distance from ICI (Figures 4 to 18).

Mercury is absorbed through stomates of leaves and stems in direct proportion to ambient air concentrations (7). Results of controlled greenhouse and field studies conducted by staff of the Standards Development Branch Phytotoxicology Section indicated that over 90% of mercury uptake by test plants (ie. lettuce, beets, radish and carrot) was through the foliage (9). Root uptake of mercury is usually not significant, due to selective physiological barriers at the root epidermis (6), although significant mercury uptake by plants from the soil has been reported (8). In the present study, the elevated concentrations of mercury in the maple foliage (Figures 4 to 18) occur over a much wider area than the elevated concentrations of mercury in the soil (Figures 5.1 to 5.5). This supports the findings that mercury in the atmosphere, rather than mercury in the soil, is the source of mercury contamination of the maple foliage.

Foliar concentrations of mercury found in the current study are very high, ranging up to 23 ug/g dry weight in 1982. Although the threshold for toxicity to mercury in tree foliage is not known, the concentrations found in the foliage are above the concentrations found to be toxic in other plants. The toxic concentration of mercury in barley is 3 ug/g dry weight (3). Foliar mercury concentrations exceeding 3 ug/g, ten times the ULN guideline (Appendix A), have occurred in eleven of the fifteen years of sampling since 1976 and are potentially phytotoxic.

The zone with foliar mercury concentrations greater than 0.3 ug/g (the ULN), has varied from year to year. This is shown in Figures 4 to 18. This area of contamination extended almost to McConnell Ave. in the late 1970s yet tended to be less than 1 km from ICI in the late 1980s. Contamination greater than twice the ULN of 0.3 ug/g, in all years, tended to be within 1 km of ICI.

Mercury stored in plant tissue is often in the methylated form. As much as 33% of foliar mercury and 25% of root mercury in beets has been reported to be in the methylated form (2). This may be a health concern if the plants are consumed; eg. lettuce from a home garden. Studies conducted around ICI in 1976 detected mercury concentrations in home-grown lettuce of more than twice the former WHO/FAO guideline of 0.05 ug/g fresh weight (11). Although the mean mercury concentration in maple foliage has decreased from 1976 to 1991 (Table 6), many stations still have foliar mercury concentrations well above the Phytotoxicology " upper limit of normal" guidelines. This suggests that garden produce may contain elevated concentrations of mercury, which may pose a health risk. In order to assess this situation, the Phytotoxicology Section in conjunction with the Cornwall District Office initiated a garden vegetable sampling program in 1993.

3.1.4 Mercury in Soil

Table 7 gives the concentration of mercury in surface soil (0-5 cm) in the vicinity of ICI for 1976, 1978, 1985 and 1991. Mean mercury concentrations were lowest in 1991 and highest in 1978. In 1978, 1985 and 1991 almost one third of the stations exceeded the ULN. Although the concentrations in the soil close to ICI are high, these data indicate that there has been a steady decrease in surface soil mercury concentrations since 1978. In order to determine whether this trend was significant, paired "t" tests were used to compare years (Appendix D). There were only 3 significant changes ($p < 0.05$); 1) between 1976 and 1985, 2) between 1985 and May of 1991 and 3) between 1985 and August of 1991. The highest concentration was in all cases in 1985. This indicates that there has been a significant decrease of approximately 40% in surface soil mercury concentration from 1985 to 1991. The reason for this is not at all clear from the mercury emission data, which show that the emissions were relatively constant from the late 1980s into the early 1990s (Figure 2). Clearly there has not been an accumulation of mercury in the soil over this time period. This may be due to the hot dry summers of the late 1980s when increased volatilization of mercury from the soil could have led to decreased surface soil mercury concentrations.

Spring and summer soil samples were collected in 1991 in an attempt to identify seasonal patterns in mercury accumulation (Table 7). Seasonal patterns of accumulation have been reported in the literature (5) where mercury that had accumulated in snow and soil in the winter had volatilized and been lost from the soil in the summer. In the current report the observed pattern of soil mercury concentration was exactly the opposite to this expected pattern. The mean soil concentration of mercury was slightly higher in August than in May, although this difference was not statistically significant ($p > 0.05$ Appendix D). This apparent contradiction may be because the seasonal pattern of accumulation in the literature assumes that the atmospheric input of mercury is more or less constant. In the current study this was not the situation. In April 1991, the month before the May soil collection, 5.381 kg of mercury was emitted to the atmosphere by ICI, whereas in July, the month before the August soil collection, more than twice the quantity, 10.98 kg of mercury, was emitted. This suggests that the accumulation and release of mercury in the soil is relatively rapid, and dependent on not only atmospheric concentrations but also weather conditions. It is assumed that a decrease

in mercury emissions from ICI would result in a rapid decrease in soil concentrations under hot summer weather conditions.

Figures 19 to 23 are contour maps of mercury concentrations in soil for the years 1976, 1978, 1985 and 1991. The 0.5 ug/g contour represents the ULN for mercury in urban soils (Appendix A). The area of contamination was greatest in 1985 and smallest in 1976. This is somewhat surprising since emissions from ICI were much higher in 1976 than in 1985 (Figure 2). This is not a reflection of the previous month's emissions as suggested in the previous paragraph, since the July emissions were 26.3 kg and 5.01 kg of mercury for 1976 and 1985, respectively. Also this is not a reflection of accumulation of mercury over the years, since the area of contamination in May of 1991 is similar to the 1976 area of contamination (Figures 19 and 22). These patterns of mercury concentration probably reflect a complex dynamics of accumulation and loss involving atmospheric concentrations of mercury, soil temperature, climate patterns and timing of sampling. Nevertheless, the overall pattern is very clear. Concentrations greater than 0.5 ug/g are within 1 km of the ICI mercury cell room.

3.1.5 Cadmium, Lead and Zinc in Soil

Table 8 gives the concentrations of cadmium, lead and zinc in surface soil collected from the sampling stations in 1991. These are the same soil samples that were collected for mercury analysis. These analyses were performed to determine whether these common contaminants of urban soils were elevated in the study area. Cadmium and lead are of particular concern to human health and zinc to plant health. At all stations, the concentrations were well below the ULN (Appendix A).

3.2 Chloride in Maple Foliage

Chloride concentrations in maple foliage (summarized in Table 9) were, on average, over twice as high at the Cornwall sampling sites than at the control sites. The highest concentrations tended to be in the vicinity of the Domtar facility (Figures 24 to 29) although from 1987 to 1991 an area of elevated chloride was evident well away from either Domtar or ICI. The Phytotoxicology Section has not established a ULN for chloride in urban tree foliage that could be directly compared to these values.

Air monitoring by the MOEE Standards Development Branch in 1986 in the vicinity of Domtar and ICI indicated that Domtar was the primary source of chlorine and chlorine dioxide emissions. ICI was not found to be a significant source during this three week study period. In the area of Domtar, air concentrations of chlorine exceeded the health and vegetation-based standard (85 ug/g 1/2 hour average) in 10 of the 37 sampling periods. All measurements for chlorine dioxide were below the corresponding health based air standard (300 ug/m^3 - 1/2 hour average)(4). In 1988, Domtar redesigned their bleach plant emission control system and installed a scrubber in July to reduce/control emissions of chlorine. No air monitoring for chlorine or chlorine dioxide has been conducted since 1986. However, mean foliar chloride concentrations were significantly less in 1989, 1990 and 1991 than 1985, 1986 or 1987 (except 1985 compared to 1991), which indicates foliar chloride concentrations have decreased subsequent to the abatement activities in 1988 (Appendix E). In the most recent three years, chloride concentrations tended to increase to the east of Domtar in the vicinity of Second St. between Pitt St. and McConnell Ave. This is the general area of the hospital. Hospital incinerators are known emitters of chlorine.

3.3 Inspections of Vegetation (1987-1991)

In recent years, the August foliar inspections for chlorine injury were primarily confined to the tree foliage collection sites. This was due to the absence of complaints, which would have meant foliar inspections at other locations. For the years 1989 to 1991, Manitoba maple trees were inspected in the residential area east of Brookdale Avenue and between Third and Fourth Street, in the vicinity of Gulf and Yates Street. This residential area is northeast of Domtar and east of ICI. The Manitoba maple foliage had upper-surface, scattered reddish necrotic lesions and bronzing. These are symptoms of oxidant damage, which can be attributed to phytotoxic concentrations of either chlorine or ozone. Both Domtar and ICI are potential emission sources of chlorine, but not of ozone. Ozone, in the ambient atmosphere, results from a photochemical reaction involving nitrogen dioxide and hydrocarbons. The major sources of these precursors are coal-fired power plants and vehicle emissions. Therefore, ambient ozone levels in the Cornwall area can become elevated regardless of the emissions from Domtar or ICI.

The observations in recent surveys revealed that the oxidant-like foliar injury on Manitoba maple was largely confined to the above-noted residential area close to Domtar and ICI. In this area in 1991, a mature Manitoba maple near the corner of Yates and Third Streets exhibited a pattern of severe injury on the side of the tree facing Domtar and ICI. Chlorine emissions may have contributed to this injury. This is the general area where chlorine damage was documented on vegetation, including Manitoba maple, in earlier years (1982-1986). However, chloride concentrations in Manitoba maple foliage in this area (Site 4), although still well above normal, have dropped considerably in recent years (0.39% in 1991 compared to 1.15% in 1987). In recent surveys (1989-1991), similar oxidant-like injury also was observed at a few Manitoba maple sites (near Sites 25, 27, and/or Site 36) remote from the companies. Hence, the possibility that ozone may be involved also can not be ruled out. On the whole, it is inconclusive as to whether chlorine was the primary cause of the oxidant-like injury that has been observed on Manitoba maples in recent surveys. The elevated chloride concentrations in maple foliage across the survey area are probably related to chronic chlorine emissions from Domtar. ICI is likely an occasional acute localized source contributing to the elevated levels at neighbouring sites.

Surveys of other maple species (silver, Norway and red maples) conducted in August of 1989 through 1991 revealed mainly tip necrosis, which is not uncommon on roadside trees in August.

3.4 Fluorides in Maple Foliage

The maple foliage collected as part of the ICI/ Domtar study was also analyzed for fluorides. This analysis was carried out in order to determine whether emissions from the Reynolds Metals aluminum smelter in Massena, New York were impacting the Cornwall area. Neither ICI nor Domtar are considered sources of fluorides. The fluoride data are included here because the Phytotoxicology Section has a policy of including the results of all analysis done in connection with a study. The concentration of fluoride in unwashed maple foliage (Table 9) was, in all cases, below the ULN of 35 ug/g for urban foliage. Although, the mean concentration in the Cornwall foliage samples was almost twice as high as in the control foliage, there was no consistent relationship between foliar concentration and distance or direction from Domtar or ICI.

4.0 SUMMARY

4.1 ICI Forest Products Emission Effects

- results of analysis of maple foliage, moss bags and soil all revealed a pattern of high mercury concentrations around the ICI Forest Products mercury cell building.

- mercury concentrations tended to decrease with increasing distance from the mercury cell building. Mercury concentrations greater than the ULN tended to be within 1 km of ICI.

- mercury emissions decreased by 74% from 1976 to 1984 and increased by 20% from 1984 to 1991; nevertheless, emissions have been decreasing since the late 1980s.

- maple foliage was found to be a good monitor of mercury emissions. Concentrations of mercury were very high around ICI and decreased with distance. The foliar mercury concentrations close to ICI may be phytotoxic.

- leafy garden vegetables grown in the immediate vicinity of ICI should be sampled and analyzed for mercury annually.

- the results of the moss bag analysis show a poor relationship between mercury emissions and mercury concentrations in the moss bags. Continuation of this type of monitoring for mercury is not recommended.

- soil mercury concentrations have significantly decreased from 1985 to 1991; however this decrease can not be attributed to reductions in emissions of mercury from ICI.

- there was no significant difference in soil mercury levels between May and August collections.

- the mercury emissions in the month prior to soil collection may have a greater impact on surface soil mercury concentrations than the season in which the sample is taken.

- ICI is likely a periodic source of acute chlorine emissions.

4.2 Domtar Emission Effects

- air monitoring in the vicinity of the Domtar/ICI complex in 1986 established that Domtar was the primary source of chlorine and chlorine dioxide emissions.

- chloride concentrations in unwashed maple foliage from 1989 to 1991 were, on average, about 26% lower than from 1985 to 1987. This suggests that the installation of the chlorine emission control system by Domtar in 1988 reduced chloride emissions; nevertheless, high chloride concentrations in maple foliage from 1989 to 1991 are clearly related to Domtar.

- vegetation inspections indicate that chronic chlorine emissions from Domtar may be contributing to oxidant-like injury on sensitive vegetation.

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Table 1: Mercury Emitted to the Atmosphere through Strong Hydrogen, End Box Ventilation and Building Ventilation by ICI Forest Products Cornwall - 1988 to 1991.

1988 Mercury Emissions	Strong Hydrogen (kg)	End Box Ventilation (kg)	Building Ventilation (kg)
January	0.0005	0.0074	6.929
February	0.0004	0.0044	7.177
March	0.0005	0.0033	7.208
April	0.0005	0.0041	5.850
May	0.0005	0.0051	10.509
June	0.0005	0.0018	9.090
July	0.0009	0.0070	12.462
August	0.0009	0.0326	9.254
September	0.0005	0.0049	9.090
October	0.0005	0.0074	5.347
November	0.0005	0.0018	4.860
December	0.0005	0.0033	4.836
SUM	0.0067	0.0831	92.612

1989 Mercury Emissions	Strong Hydrogen (kg)	End Box Ventilation (kg)	Building Ventilation (kg)
January	0.0005	0.0042	6.184
February	0.0090	0.0022	5.760
March	0.0005	0.0023	2.743
April	0.0005	0.0018	4.725
May	0.0005	0.0028	8.370
June	0.0013	0.0117	9.540
July	0.0009	0.0149	16.647
August	0.0009	0.0237	10.788
September	0.0018	0.0067	12.060
October	0.0005	0.0056	8.323
November	0.0009	0.0081	4.410
December	0.0005	0.0023	1.953
SUM	0.0178	0.0863	91.503

1990 Mercury Emissions	Strong Hydrogen (kg)	End Box Ventilation (kg)	Building Ventilation (kg)
January	0.0005	0.0019	5.534
February	0.0005	0.0027	8.415
March	0.0005	0.0019	9.672
April	0.0050	0.0023	5.400
May	0.0014	0.0033	8.091
June	0.0032	0.0036	10.080
July	0.0000	0.0307	15.345
August	0.0032	0.0019	8.835
September	0.0032	0.0014	7.470
October	0.0056	0.0205	4.371
November	0.0158	0.0117	10.215
December	0.0642	0.0037	6.273
SUM	0.1031	0.0856	99.701

1991 Mercury Emissions	Strong Hydrogen (kg)	End Box Ventilation (kg)	Building Ventilation (kg)
January	0.0642	0.0056	1.767
February	0.0743	0.0319	4.578
March	0.0288	0.0130	5.022
April	0.0297	0.0014	5.355
May	0.0544	0.0070	6.185
June	0.0216	0.0059	6.300
July	0.0060	0.0074	10.974
August	0.0028	0.0042	9.347
September	0.0400	0.0152	7.352
October	0.0081	0.0243	5.490
November	0.0059	0.0162	4.230
December	0.0045	0.0090	2.655
SUM	0.3403	0.1411	69.255

Data reported by ICI to the MOE Cornwall District Office

Table 2 : Mercury in Moss Bags Exposed for Periods of One Month on the Roof of the Mercury Cell Room of ICI Forest Products, Cornwall , Ontario - 1987 to 1989

1987 Mercury Concentration in Moss Bags (ug/g, dry wt.)													
Station Number	January	February	March	April	May	June	July	August	September	October	November	December	Mean
1	ND	470	530	110	440	1500	2600	ND	2200	2100	1000	1400	1235
2	ND	650	420	220	340	340	890	ND	390	900	1100	980	623
4	ND	1300	380	280	540	770	890	ND	550	840	430	930	691
5	ND	580	440	320	350	310	790	ND	2600	720	2300	1700	1011
7	ND	820	410	470	470	450	680	ND	740	1500	380	820	674
Mean	ND	764	436	280	428	674	1170	ND	1296	1212	1042	1166	846.8
*Hg emissions	3.07	4.22	4.99	4.48	8.28	10.73	9.31	8.71	10.09	8.79	7.79	8.09	7.37
**RF	ND	181:1	87:1	63:1	52:1	63:1	126:1	ND	128:1	138:1	134:1	144:1	115:1
1988 Mercury Concentration in Moss Bags (ug/g, dry wt.)													
Station Number	January	February	March	April	May	June	July	August	September	October	November	December	Mean
1	1200	1000	1000	760	510	1600	1400	1100	990	540	380	670	929
2	610	180	320	280	230	340	360	320	310	110	100	360	293
4	550	710	840	780	250	950	1200	690	580	410	690	1000	720
5	470	250	560	500	180	460	540	310	360	200	280	350	372
7	940	280	360	300	300	850	830	260	320	120	120	260	412
Mean	754	484	616	524	294	840	866	536	512	276	314	528	545
*Hg emissions	6.94	7.18	7.21	5.85	10.51	9.09	12.47	9.29	9.1	5.35	4.86	4.84	7.72
**RF	109:1	67:1	85:1	90:1	28:1	92:1	69:1	58:1	56:1	52:1	65:1	109:1	71:1

* cell room mercury emissions reported by ICI

** mean cell room moss bag concentration : reported cell room emissions

ND - no data

Table 2 continued

1989 Mercury Concentration in Moss Bags (ug/g, dry wt.)													
Station Number	January	February	March	April	May	June	July	August	September	October	November	December	Mean
1	790	660	280	290	290	530	430	ND	ND	480	1100	340	519
2	200	270	87	140	96	260	190	ND	ND	160	170	520	209
4	980	1200	540	440	76	450	510	ND	ND	490	1800	700	719
5	650	600	230	160	160	170	300	ND	ND	190	170	1400	403
7	600	390	160	-	140	86	190	ND	ND	380	300	450	300
Mean	644	624	259	258	152	299.2	324	ND	ND	340	708	682	430
*Hg emissions	6.19	5.76	2.75	4.73	8.37	9.55	16.66	10.81	12.07	8.33	4.42	1.96	
**Ratio	104:1	108:1	94:1	55:1	18:1	31:1	19:1	ND	ND	41:1	160:1	348:1	

* cell room mercury emissions reported by ICI

** mean cell room moss bag concentration : reported cell room emissions

ND - no data

TABLE 3 : Mercury and Chloride Concentrations in Moss Bags Exposed Monthly During 1987 in Cornwall, Ontario

Station Number	Distance (m) and Direction from ICI	Domtar	Moss Bag Exchange Date - 1987 Jan	Feb 09	March 10	April 09	May 15	June 10	July 02	August 04	Sept	Oct	Nov 06	Dec 02	Mean
							Mercury Concentration (ug/g, dry wt.)								
108	320 N	700 N	ND	2.60	1.30	ND	2.00	1.60	3.80	9.20	ND	ND	1.50	1.20	2.90
114	700 NE	1000 NE	ND	0.81	0.76	0.40	0.57	0.45	0.64	1.40	ND	ND	0.58	0.29	0.65
116	1080 NE	1370 NE	ND	0.31	0.45	0.24	0.28	0.31	0.50	1.30	ND	ND	0.91	0.28	0.51
125	2400 NE	2700 NE	ND	0.34	0.55	0.28	0.49	ND	0.78	1.70	ND	ND	0.31	0.27	0.59
129	3100 NE	3400 NE	ND	0.70	0.42	0.22	0.41	0.22	0.70	20.00	ND	ND	0.32	0.34	2.59
128	5900 NE	6200 NE	ND	0.34	0.46	0.28	0.42	0.32	2.50	1.30	ND	ND	0.26	0.90	0.75
122	5500 NW	5750 NW	ND	0.28	0.31	0.25	0.29	0.26	0.39	0.74	ND	ND	0.22	0.37	0.34
Mean			ND	0.77	0.61	0.28	0.64	0.53	1.33	5.1	ND	ND	0.59	0.52	1.17
							Chloride Concentration (Percent, dry wt.)								
108	320 N	700 N	ND	0.51	0.58	ND	0.07	0.07	0.25	0.12	ND	ND	0.17	0.03	0.22
114	700 NE	1000 NE	ND	0.48	0.74	0.08	0.05	0.03	0.08	0.01	ND	ND	0.10	0.01	0.18
116	1080 NE	1370 NE	ND	0.08	0.13	0.04	0.04	0.02	0.05	0.02	ND	ND	0.04	0.01	0.05
125	2400 NE	2700 NE	ND	0.14	0.30	ND	0.02	ND	0.05	0.01	ND	ND	0.03	0.01	0.08
129	3100 NE	3400 NE	ND	0.17	0.04	0.05	0.17	0.02	0.05	0.02	ND	ND	0.03	0.01	0.06
128	5900 NE	6200 NE	ND	0.08	0.14	0.09	0.05	0.02	0.13	0.02	ND	ND	0.06	0.01	0.07
122	5500 NW	5750 NW	ND	0.06	0.13	0.15	0.03	0.03	0.03	0.01	ND	ND	0.02	0.01	0.05
Mean			ND	0.22	0.29	0.08	0.06	0.03	0.09	0.03	ND	ND	0.06	0.01	0.1

ND - no data

TABLE 4 : Mercury and Chloride Concentrations in Moss Bags Exposed Monthly During 1988 in Cornwall, Ontario

Station Number	Distance (m) and Direction from ICI	Domtar	Moss Bag Exchange Date - 1988 Jan 04	Feb 03	March 02	April 31	May 02	June 01	July 30	August 03	Sept 08	Oct	Nov	Dec	Mean
							Mercury Concentration (ug/g, dry wt.)								
108	320 N	700 N	0.95	1.50	1.20	1.10	0.64	2.60	4.20	1.30	1.70	ND	1.00	0.82	1.55
114	700 NE	1000 NE	0.36	0.52	0.44	0.19	0.25	0.56	1.50	0.57	0.61	ND	0.39	0.35	0.52
116	1080 NE	1370 NE	0.15	0.15	0.17	0.14	0.14	0.39	0.69	0.48	0.30	ND	0.28	0.25	0.28
125	2400 NE	2700 NE	0.21	0.14	0.11	0.14	0.16	0.46	1.40	0.46	0.38	ND	0.27	0.25	0.36
129	3100 NE	3400 NE	0.18	0.19	0.22	0.16	0.13	ND	ND	ND	ND	ND	ND	ND	0.18
128	5900 NE	6200 NE	0.14	0.15	0.09	0.13	0.18	0.37	2.20	0.38	0.33	ND	0.30	0.2	0.41
122	5500 NW	5750 NW	0.10	0.10	0.09	0.12	0.12	0.25	0.65	0.33	0.28	ND	0.30	ND	0.23
Mean			0.3	0.39	0.33	0.28	0.23	0.77	1.77	0.59	0.6	ND	0.42	0.37	0.53
							Chloride Concentration (Percent, dry wt.)								
108	320 N	700 N	0.81	1.23	0.35	0.59	0.03	ND	0.02	0.15	0.13	ND	0.02	0.11	0.34
114	700 NE	1000 NE	0.97	1.48	0.94	0.31	0.01	0.08	0.02	0.06	0.03	ND	0.03	0.04	0.36
116	1080 NE	1370 NE	0.08	0.19	0.11	0.20	0.01	ND	0.02	0.04	0.03	ND	0.01	0.01	0.07
125	2400 NE	2700 NE	0.36	0.72	0.38	0.26	0.01	0.04	ND	0.04	0.03	ND	0.01	0.01	0.19
129	3100 NE	3400 NE	0.14	0.24	0.19	0.17	0.01	ND	ND	ND	ND	ND	ND	ND	0.15
128	5900 NE	6200 NE	0.08	0.18	0.11	0.13	0.01	0.18	0.02	0.05	0.11	ND	0.05	0.03	0.09
122	5500 NW	5750 NW	0.08	0.25	0.08	0.08	0.01	0.03	0.01	0.01	0.01	ND	0.00	ND	0.06
Mean			0.36	0.61	0.31	0.25	0.01	0.08	0.02	0.06	0.06	ND	0.021	0.04	0.18

ND - no data

TABLE 5 : Mercury and Chloride Concentrations in Moss Bags Exposed Monthly During 1989 in Cornwall, Ontario

Station Number	Distance (m) and Direction from ICI	Domtar	Moss Bag Exchange Date - 1989 Jan 10	Feb 07	March 9	April 31	May 01	June 6	July 11	August 17	Sept	Oct 10	Nov	Dec 18	Mean
							Mercury Concentration (ug/g, dry wt.)								
108	320 N	700 N	2.60	1.20	1.50	1.40	1.60	1.20	5.90	3.70	ND	1.80	ND	ND	2.32
114	700 NE	1000 NE	1.70	1.20	0.92	0.87	0.49	6.90	21.00	27.00	ND	44.00	ND	0.50	10.46
116	1080 NE	1370 NE	0.40	0.25	0.57	0.34	0.24	0.33	0.70	4.20	ND	1.60	ND	0.22	0.89
125	2400 NE	2700 NE	0.64	ND	ND	0.53	0.46	0.31	0.30	2.00	ND	9.40	ND	ND	1.95
129	3100 NE	3400 NE	ND	ND	ND	ND	ND	0.26	0.30	45.00	ND	0.27	ND	0.26	9.22
128	5900 NE	6200 NE	0.55	0.23	1.50	0.56	0.46	0.27	0.33	1.10	ND	0.46	ND	0.22	0.57
122	5500 NW	5750 NW	0.88	0.44	0.60	0.47	0.52	0.20	0.29	1.90	ND	0.33	ND	0.21	0.58
Mean			1.13	0.66	1.02	0.7	0.63	1.35	4.12	12.13	ND	8.27	ND	0.28	3.71
							Chloride Concentration (Percent, dry wt.)								
108	320 N	700 N	0.79	0.48	0.56	0.15	0.18	0.11	0.07	0.13	ND	0.13	ND	0.64	0.32
114	700 NE	1000 NE	0.63	1.60	0.68	0.29	0.05	0.07	0.09	0.11	ND	0.21	ND	1.70	0.54
116	1080 NE	1370 NE	0.05	0.07	0.07	0.03	0.02	0.02	0.01	0.07	ND	0.06	ND	0.11	0.05
125	2400 NE	2700 NE	0.25	ND	ND	0.04	0.03	0.02	0.02	0.04	ND	0.15	ND	ND	0.08
129	3100 NE	3400 NE	ND	ND	ND	ND	ND	0.03	0.01	0.06	ND	0.05	ND	0.20	0.07
128	5900 NE	6200 NE	0.09	0.12	0.08	0.02	0.08	0.10	0.01	0.22	ND	0.05	ND	0.21	0.10
122	5500 NW	5750 NW	0.21	0.11	0.07	0.04	0.06	0.03	0.02	0.06	ND	0.03	ND	0.26	0.09
Mean			0.336	0.476	0.292	0.095	0.07	0.054	0.033	0.098	ND	0.097	ND	0.52	0.19

ND - no data

TABLE 6: Mercury concentration in unwashed maple foliage collected in Cornwall, 1976 - 1991

Station Number	Distance (m) and Direction from the ICI Hg Cell Room	Maple Species (1989)	Foliar Mercury Concentration (ug/g, dry wt.) *														
			1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1989	1990	1991
1	360 N	Silver	6.30	4.10	0.61	1.30	2.00	1.60	16.00	1.20	1.10	1.30	0.84	1.80	0.26	0.27	0.24
2	360 NNE	Manitioba	15.00	18.00	2.00	2.70	4.90	3.70	23.00	1.70	1.90	3.70	2.90	10.30	0.85	0.92	1.90
4	240 E	Manitoba	2.70	3.50	5.30	2.90	14.00	7.30	9.80	3.00	3.40	3.80	6.80	8.60	3.80	8.75	2.60
6	400 ENE	Sugar	1.60	7.20	3.40	2.00	4.20	2.30	4.20	2.30	2.70	1.90	3.20	3.00	2.50	4.25	2.90
8	560 E	Red	0.60	1.30	1.00	0.59	1.20	0.56	0.64	0.44	0.49	0.37	0.66	0.75	0.37	0.17	0.59
9	600 ENE	Silver	1.30	3.80	1.50	1.10	2.00	0.92	1.70	0.94	1.00	0.77	1.20	1.65	0.65	0.62	0.89
10	750 NNE	Silver	1.20	1.10	0.32	0.45	0.65	0.29	0.37	0.35	0.32	0.53	0.34	0.45	0.18	0.01	0.21
11	1120 NE	Silver	1.30	0.88	0.45	0.69	0.74	0.31	0.81	0.34	0.42	0.52	0.42	1.15	0.35	0.01	0.46
12	680 NW	Silver	0.18	0.18	0.07	0.18	0.20	0.06	0.08	0.03	0.05	0.03	0.10	0.20	0.02	0.08	0.04
14	240 SW	Norway	1.50	1.10	0.74	1.60	1.00	0.69	1.20	0.62	0.94	0.93	2.20	0.96	0.38	0.73	1.10
16	760 ESE	Silver	0.42	0.37	0.28	0.25	0.79	0.54	0.18	0.21	0.29	0.17	0.19	0.27	0.15	0.03	0.23
19	760 SW	Manitoba	ND	ND	0.15	0.18	0.69	0.20	0.64	0.44	0.16	0.25	0.48	0.86	0.18	0.22	0.25
21	720 SSE	Silver	0.13	0.45	0.33	0.28	0.39	0.40	0.23	0.36	0.46	0.17	0.20	0.44	0.31	0.13	0.31
22	1700 E	Silver	ND	ND	0.15	0.11	0.20	0.18	0.23	0.14	0.14	0.09	0.14	0.10	0.13	0.07	0.09
23	760 N	Silver	0.36	0.28	0.22	0.45	0.32	0.10	0.17	0.08	0.10	0.08	0.06	0.10	0.04	0.04	0.04
25	1440 NNE	Manitoba	0.71	0.31	0.22	0.37	0.28	0.26	0.57	0.18	0.22	0.36	0.14	0.21	0.14	0.09	0.05
27	840 E	Silver	0.45	0.72	0.57	0.40	0.55	0.51	0.54	0.31	0.31	0.25	0.38	0.41	0.22	0.06	0.35
32	1880 ENE	Silver	0.22	0.38	0.23	0.18	0.32	0.28	0.36	0.23	0.20	0.11	0.17	0.29	0.15	0.09	0.12
33	700 W	Norway	0.25	0.18	0.15	0.22	0.21	0.20	0.24	0.14	0.05	0.05	0.11	0.27	0.11	0.09	0.04
35	1740 WSW	Silver	0.09	0.09	0.04	0.23	0.16	0.10	0.09	0.10	0.07	0.06	0.08	0.20	0.03	0.05	0.03
36	2300 NE	Manitoba	ND	0.26	0.18	0.15	0.19	0.22	0.09	0.13	0.24	0.20	0.18	0.48	0.09	0.13	0.14
37	3500 NE	Norway	ND	0.20	0.12	0.11	0.18	0.14	0.10	0.11	0.12	0.11	0.11	0.19	0.10	0.08	0.04
Mean			1.906	2.220	0.820	0.747	1.599	0.948	2.784	0.607	0.667	0.716	0.950	1.485	0.500	0.765	0.574
Median			0.655	0.585	0.300	0.385	0.600	0.300	0.455	0.325	0.300	0.280	0.270	0.445	0.185	0.105	0.235
Controls	(>20 km W)	Manitoba	ND	0.07	0.04	0.06	0.04	0.12	0.05	0.04	0.04	0.03	0.04	0.04	0.06	0.03	0.03
		Silver	0.05	0.06	0.05	0.04	0.05	0.05	0.12	0.04	0.04	0.05	0.03	0.03	0.05	0.03	0.02
		Norway	ND	ND	ND	ND	ND	ND	ND	ND	0.03	0.05	0.01	ND	0.04	0.04	0.02

* Average of triplicate sample results from 1976 - 1984 and average of duplicate sample results from 1985 to 1991

Underlined data exceed the Phytotoxicology "upper limit of normal guideline" for mercury in urban tree foliage of 0.3 ug/g (see appendix)

ND - no data

Table 7: Mercury Concentrations (ug/g, dry weight) * in Surface Soil (0-5 cm) Collected in the Vicinity of ICI, Cornwall - 1976, 1978, 1985 and 1991.

Station number	Distance (m) and Direction from Hg Cell Room	1976 Aug.	1978 Aug.	1985 Aug.	1991 May	1991 Aug.
1	360 N	2.10	2.20	2.60	1.07	1.55
2	360 NNE	2.10	4.30	3.30	1.70	1.85
4	240 E	2.60	4.20	3.70	1.75	1.95
6	100 ENE	0.93	1.30	0.43	0.84	0.81
8	560 E	0.26	0.27	0.48	0.39	0.38
9	600 ENE	0.56	0.60	0.97	0.36	0.27
10	750 NNE	0.28	0.31	0.51	0.29	0.27
11	1120 NE	0.27	0.30	0.26	0.39	0.43
12	680 NW	0.05	0.02	0.06	0.06	0.04
14	240 SW	0.40	0.61	0.79	0.60	0.83
16	760 ESE	0.14	0.20	0.34	0.18	0.17
19	760 SW	ND	0.33	1.40	0.23	0.23
21	720 SSE	0.19	0.28	0.46	0.48	0.67
22	1700 E	NS	0.14	0.26	0.18	0.15
23	760 N	0.07	0.14	0.12	0.07	0.06
25	1400 NNE	0.23	0.15	0.32	0.14	0.20
27	840 E	0.48	0.23	0.36	0.22	0.22
32	1880 ENE	0.15	0.13	0.20	0.60	0.57
33	700 W	0.08	1.75	0.15	0.11	0.08
35	1740 WSW	0.08	0.06	0.09	0.11	0.08
36	2300 NW	ND	0.14	0.12	0.07	0.06
37	3500 NE	ND	0.08	0.09	0.07	0.05
Mean soil Hg concentration		0.589	0.806	0.773	0.450	0.494
Mean concentration in rural control soil samples				0.07	0.05	0.04
% of stations exceeding ULN **		22	32	32	27	32

* Average of triplicate sample results in 1976 and 1978 and the average of duplicate sample results in 1985 and 1991.

** Phytotoxicology section "Upper Limit of Normal" mercury concentration in urban soil (0-5 cm depth) is 0.5 ug/g (see appendix). Data exceeding the ULN are underlined.

ND - no data

Table 8: Cadmium, Lead and Zinc Concentrations (ug/g, dry weight) * in Surface Soil (0-5cm) Collected in the Vicinity of ICI Forest Products, Cornwall - May and August 1991

Station number	Distance (m) and Direction from ICI Hg Cell Room	Cadmium	Lead	Zinc
1	360 N	0.39	55	105
2	360 NNE	0.53	73	83
4	240 E	0.34	63	100
6	100 ENE	0.47	60	105
8	560 E	0.33	40	77
9	600 ENE	0.34	59	83
10	750 NNE	0.42	73	93
11	1120 NE	0.67	150	170
12	680 NW	0.42	32	71
14	240 SW	0.65	120	105
16	760 ESE	0.57	150	150
19	760 SW	0.41	28	68
21	720 SSE	0.45	74	81
22	1700 E	0.60	108	74
23	760 N	0.47	62	73
25	1400 NNE	0.91	100	136
27	840 E	0.72	88	92
32	1880 ENE	0.66	120	78
33	700 W	0.45	41	71
35	1740 WSW	0.38	21	46
36	2300 NW	0.42	12	71
37	3500 NE	0.49	29	103
Mean soil concentration		0.50	71	92
MOE "upper limit of normal" for urban soils (0-5 cm)		4	500	500
Mean concentration in rural control soil samples		0.49	21	63

* Average of duplicate sample results

ULN - Phytotoxicology "Upper Limit of Normal Guideline" for urban soil (see appendix)

Table 9: Chloride and Fluoride Concentrations * in Unwashed Maple Foliage Collected in Cornwall - 1985 to 1991

Station Number	Distance (m) and Direction from Domtar	Maple Species (1989)	Chloride Concentration (Percent,dry wt) 1985	1986	1987	1989	1990	1991	Fluoride Concentration (ug/g, dry wt.) 1990	1991
1	670 N	Silver	0.20	0.33	0.39	0.20	0.18	0.21	7.35	14.50
2	670 NNE	Manitoba	0.44	0.34	0.38	0.25	0.24	0.20	8.45	7.40
4	420 NE	Manitoba	0.93	0.96	1.15	0.50	0.59	0.39	24.00	10.50
6	600 NE	Sugar	0.40	0.34	0.29	0.18	0.19	0.21	4.25	6.05
8	690 NE	Red	0.32	0.26	0.25	0.13	0.15	0.22	5.20	5.10
9	810 NE	Silver	0.73	0.68	0.57	0.40	0.37	0.53	14.65	15.00
10	1060 NE	Silver	0.40	0.28	0.26	0.25	0.20	0.29	7.60	8.30
11	1370 NE	Silver	0.28	0.42	0.34	0.09	0.15	0.16	12.00	13.00
12	960 NNW	Silver	0.16	0.21	0.75	0.20	0.15	0.30	3.00	4.40
14	210 NW	Norway	0.55	0.94	0.75	0.77	0.68	0.71	6.10	6.85
16	710 E	Silver	0.13	0.18	0.17	0.09	0.10	0.11	6.60	6.25
19	580 WSW	Manitoba	0.19	0.34	0.27	0.15	0.24	0.30	7.60	5.90
21	540 SE	Silver	0.38	0.80	0.78	0.27	0.27	0.34	16.00	11.00
22	1810 ENE	Silver	0.47	0.60	0.57	1.00	1.20	0.83	7.15	12.00
23	1100 N	Silver	0.12	0.23	0.21	0.10	0.13	0.13	7.00	9.20
25	1730 NNE	Manitoba	0.33	0.21	0.23	0.26	0.19	0.23	7.40	6.00
27	920 ENE	Silver	0.32	0.45	0.44	0.24	0.29	0.32	5.65	9.15
32	2000 NE	Silver	0.32	0.54	0.64	0.62	0.45	0.53	10.50	9.45
33	790 NW	Norway	0.60	0.64	0.68	0.36	0.28	0.50	2.30	3.20
35	1620 WSW	Silver	0.67	0.32	0.28	0.16	0.10	0.20	5.00	5.45
36	2580 NE	Manitoba	0.22	0.20	0.17	0.09	0.12	0.16	6.25	7.70
37	3700 NE	Norway	0.28	0.36	0.32	0.43	0.29	0.56	7.05	7.00
Mean			0.384	0.438	0.450	0.306	0.296	0.335	8.232	8.336
ULN			NG	NG	NG	NG	NG	NG	35	35
Controls (>20 km W)		Manitoba	0.08	0.11	0.12	0.10	0.06	0.05	4.85	3.55
		Silver	0.06	0.06	0.03	0.20	0.04	0.02	4.85	2.35
		Norway	0.20	0.34	ND	0.21	0.14	0.11	4.40	1.95

* 3 replicate sample per year
NG - no guideline, the ULN is not established
ULN - Phytotoxicology "Upper Limit of Normal" guideline (see appendix)

Figure 1: Map of Cornwall Including the Location of ICI Forest Products, Domtar and Sampling Stations

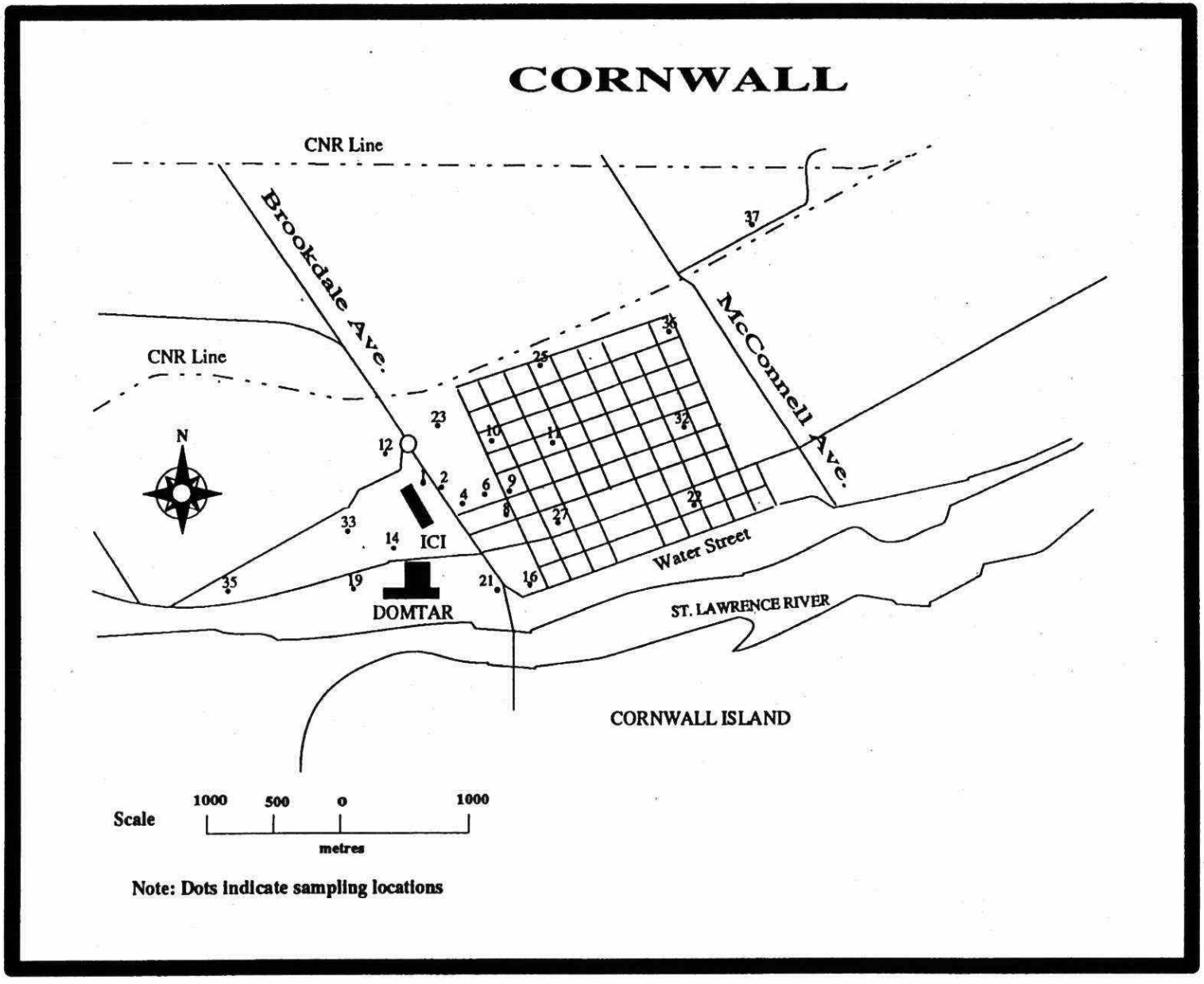
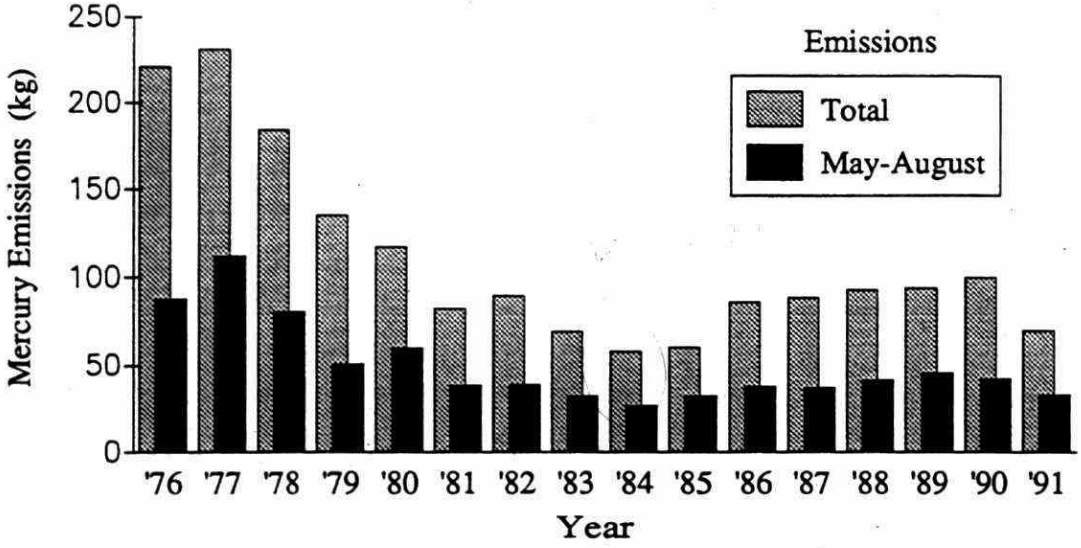


Figure 2: ICI Cell Room Mercury Emissions* to the Atmosphere from 1976 to 1991



* Sum of Hg emitted in building ventilation, strong hydrogen and end box ventilation (information provided by ICI Forest Products, Cornwall)

Figure 3: May to August ICI mercury emissions to the atmosphere compared to the mercury concentration in maple foliage

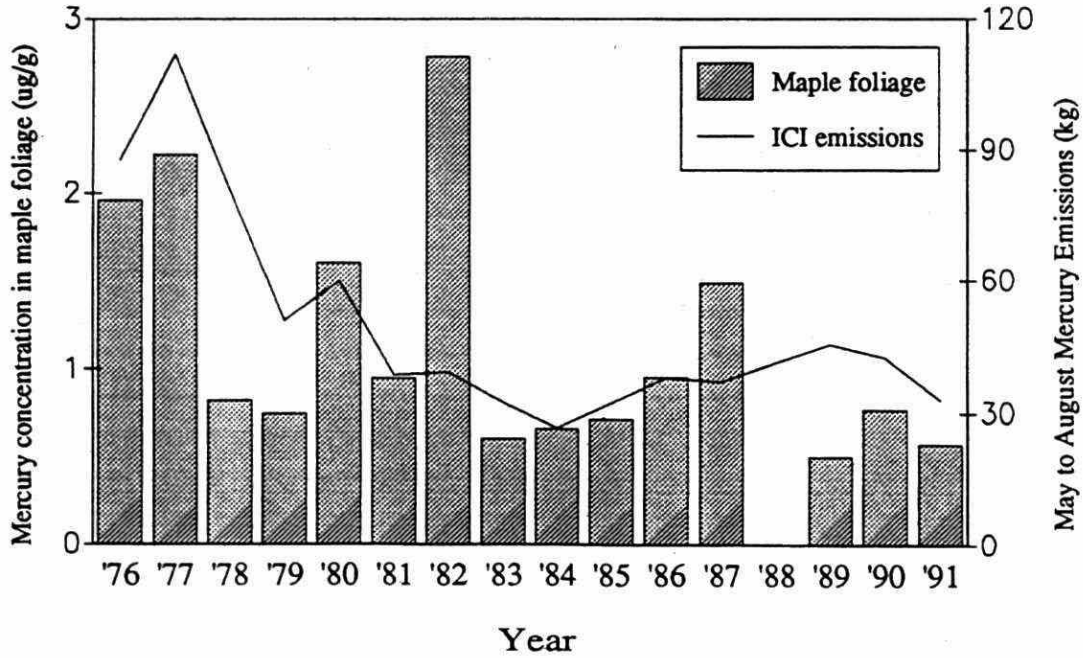


Figure 4: Contour Map of the Mercury Concentration (ug/g, dry wt) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall 1976

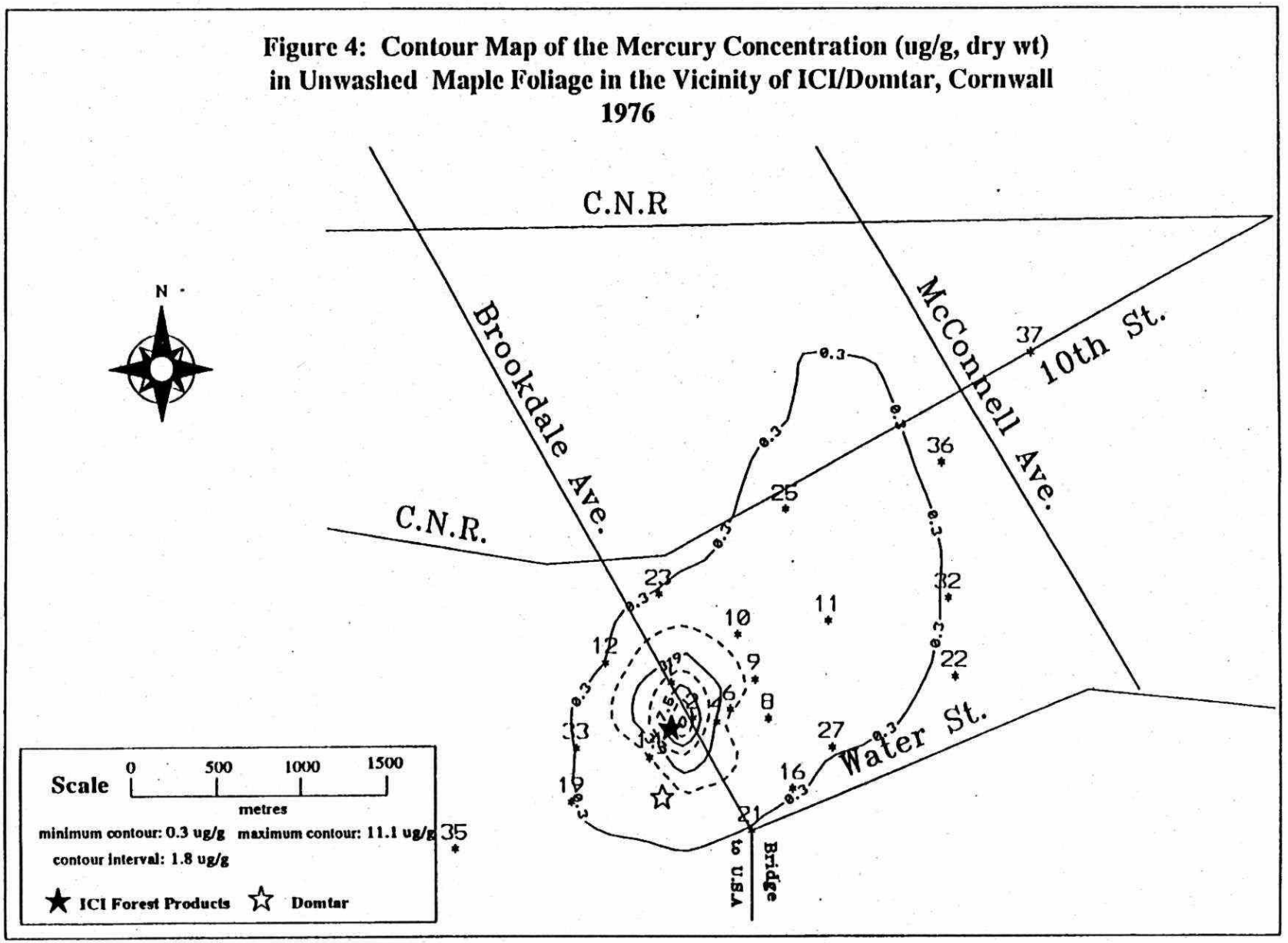


Figure 5: Contour Map of the Mercury Concentration (ug/g, dry wt) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall 1977

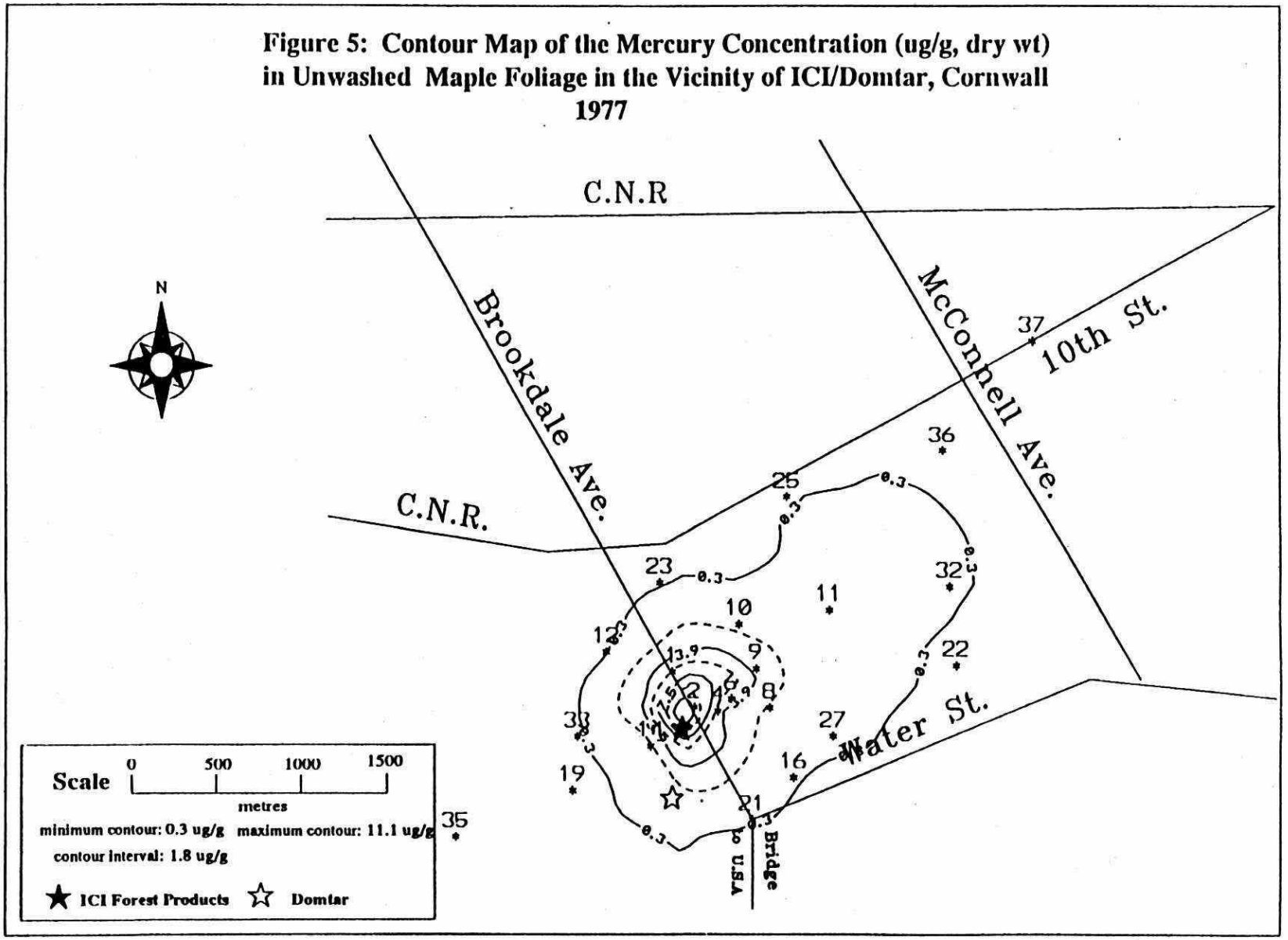


Figure 6: Contour Map of the Mercury Concentration (ug/g, dry wt) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall 1978

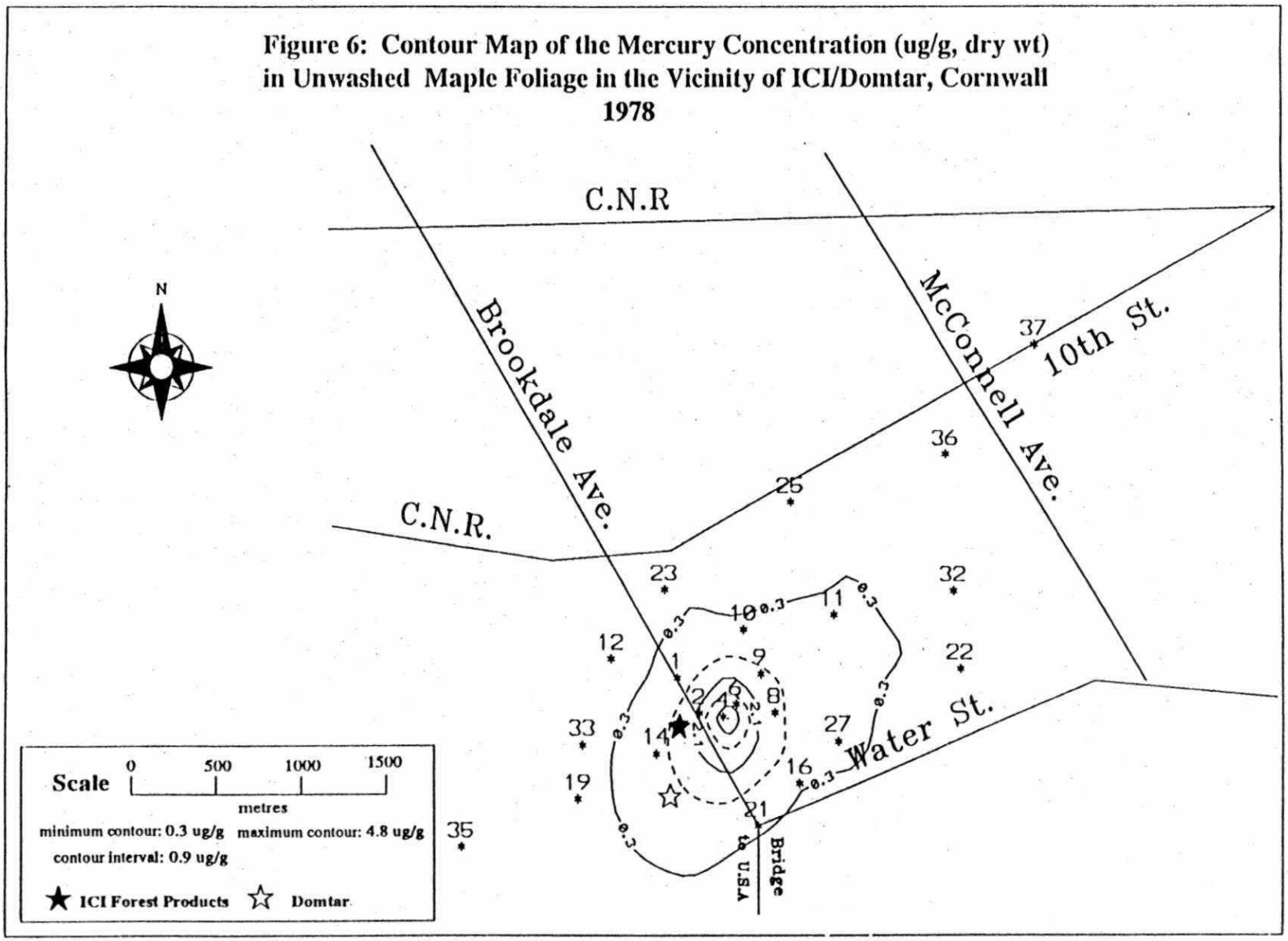


Figure 7: Contour Map of the Mercury Concentration (ug/g, dry wt) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall 1979

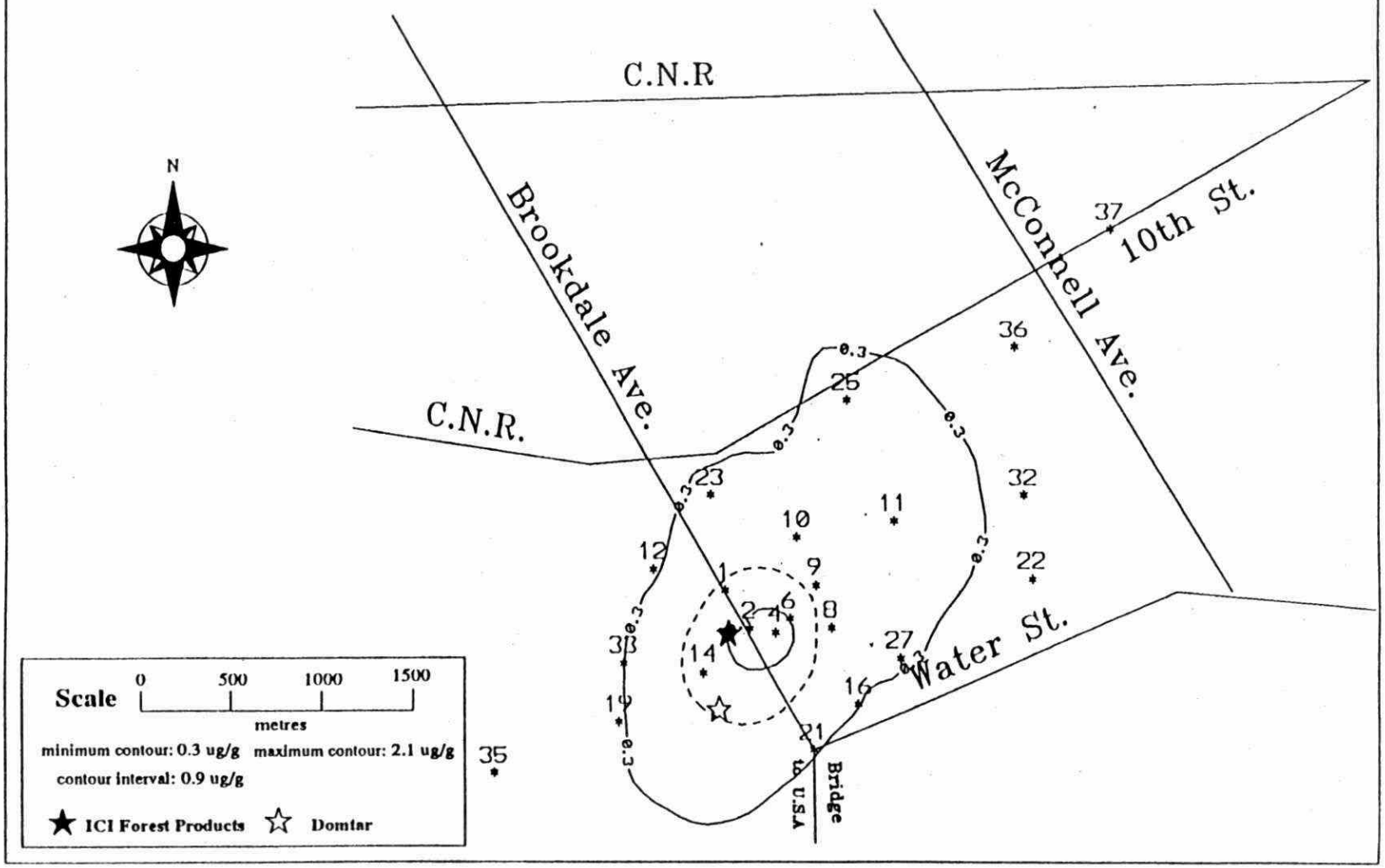


Figure 8: Contour Map of the Mercury Concentration (ug/g, dry wt) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall 1980

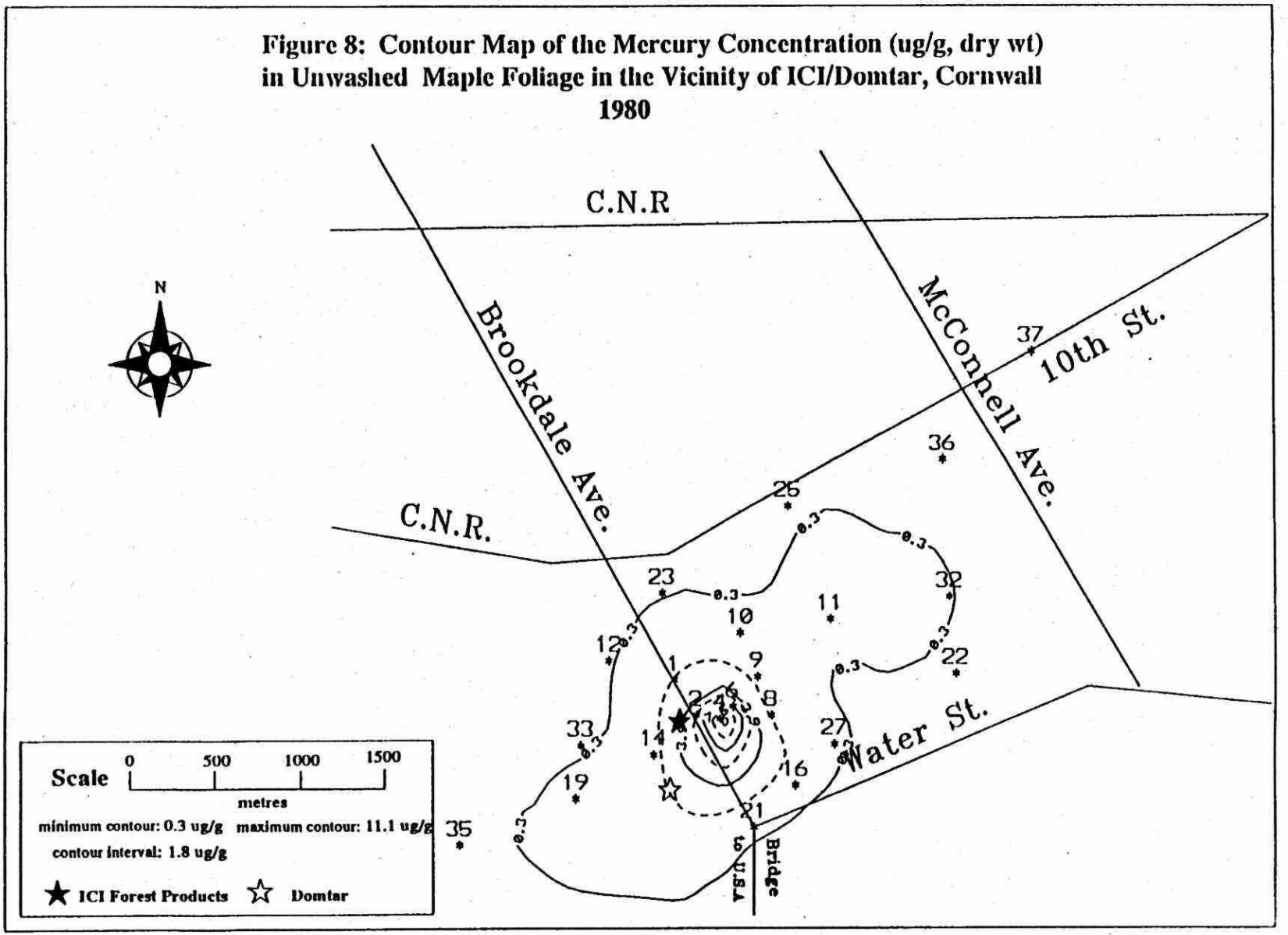


Figure 9: Contour Map of the Mercury Concentration (ug/g, dry wt) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall 1981

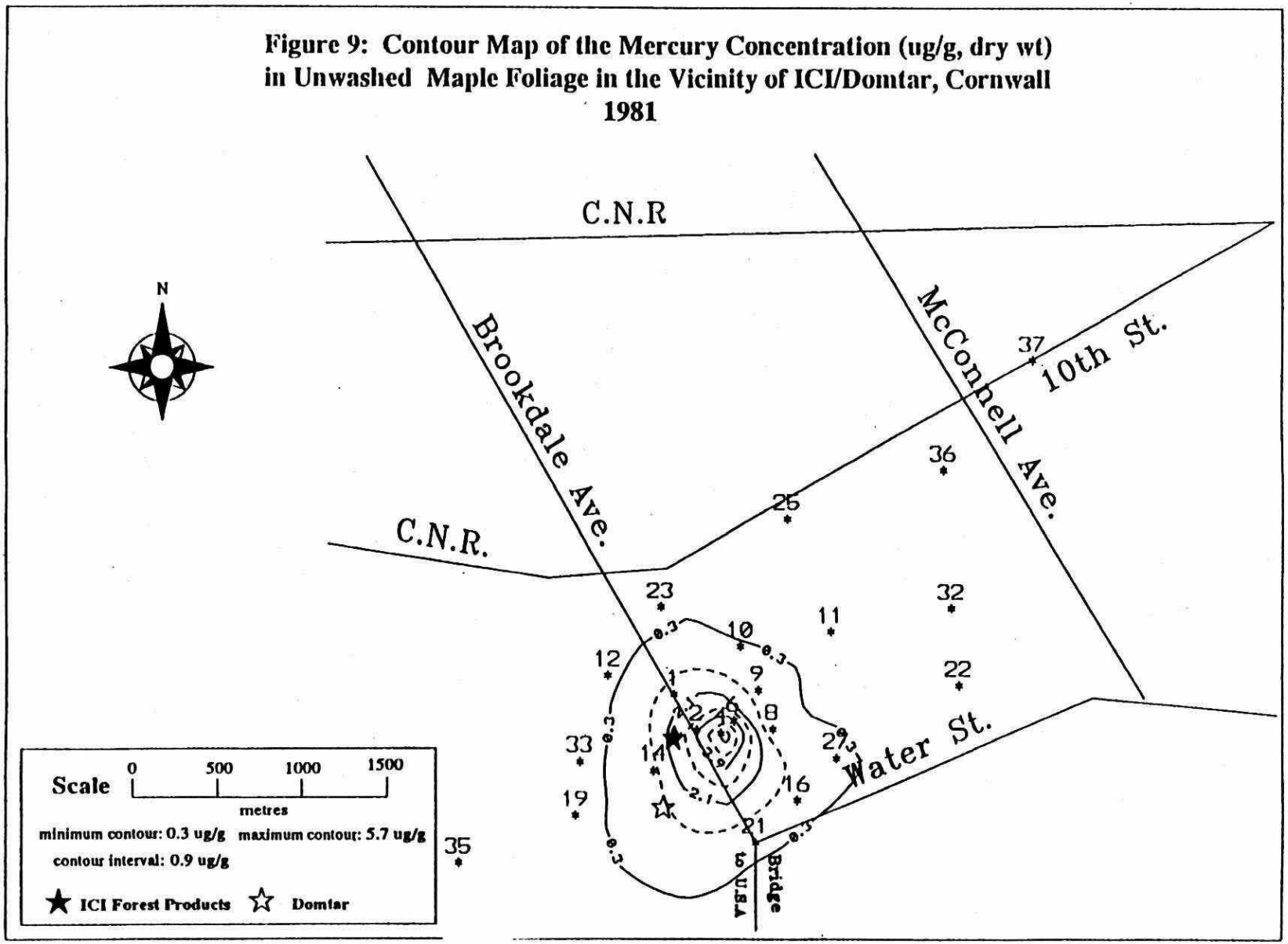


Figure 10: Contour Map of the Mercury Concentration (ug/g, dry wt) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall 1982

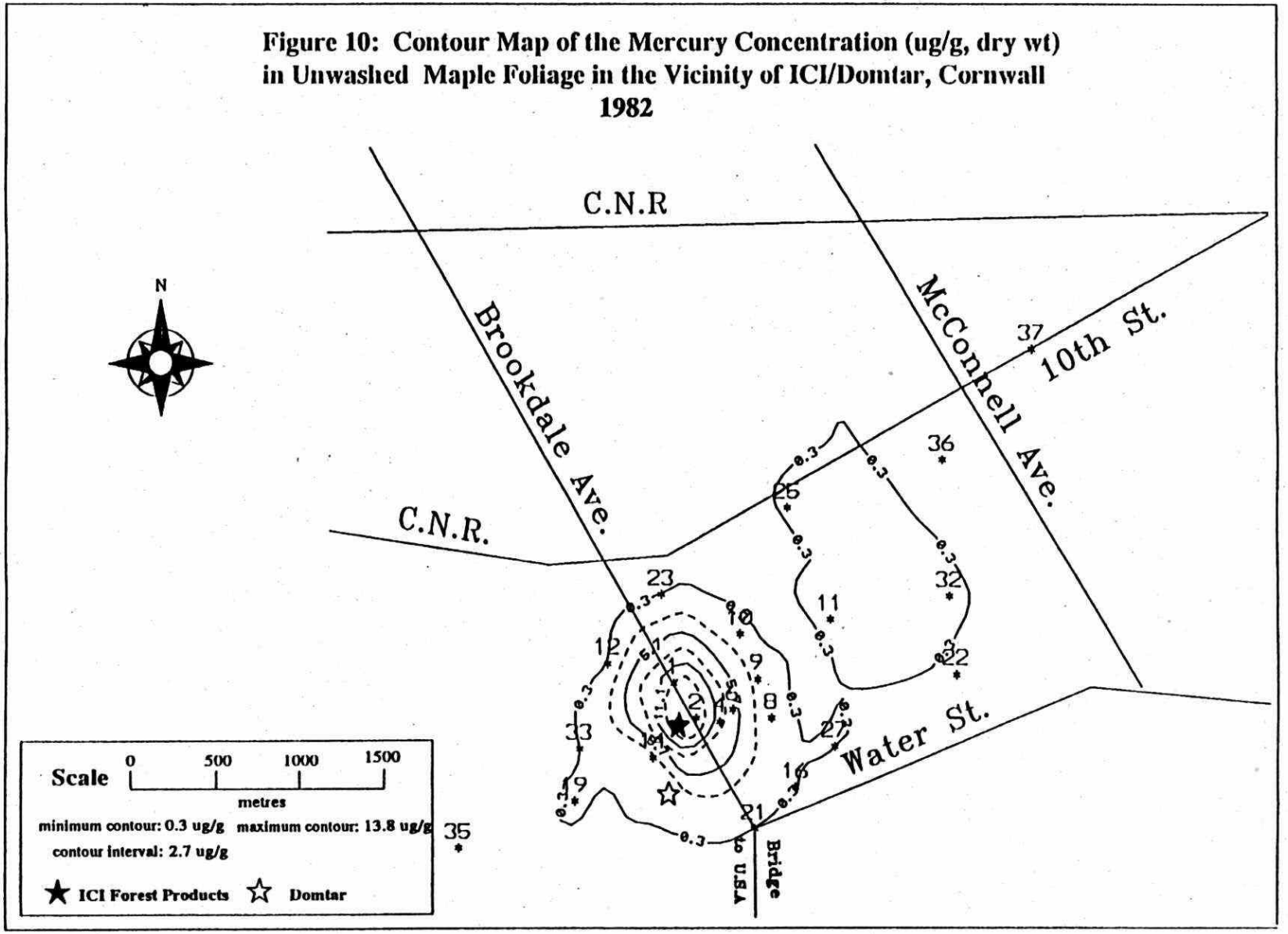


Figure 11: Contour Map of the Mercury Concentration (ug/g, dry wt) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall 1983

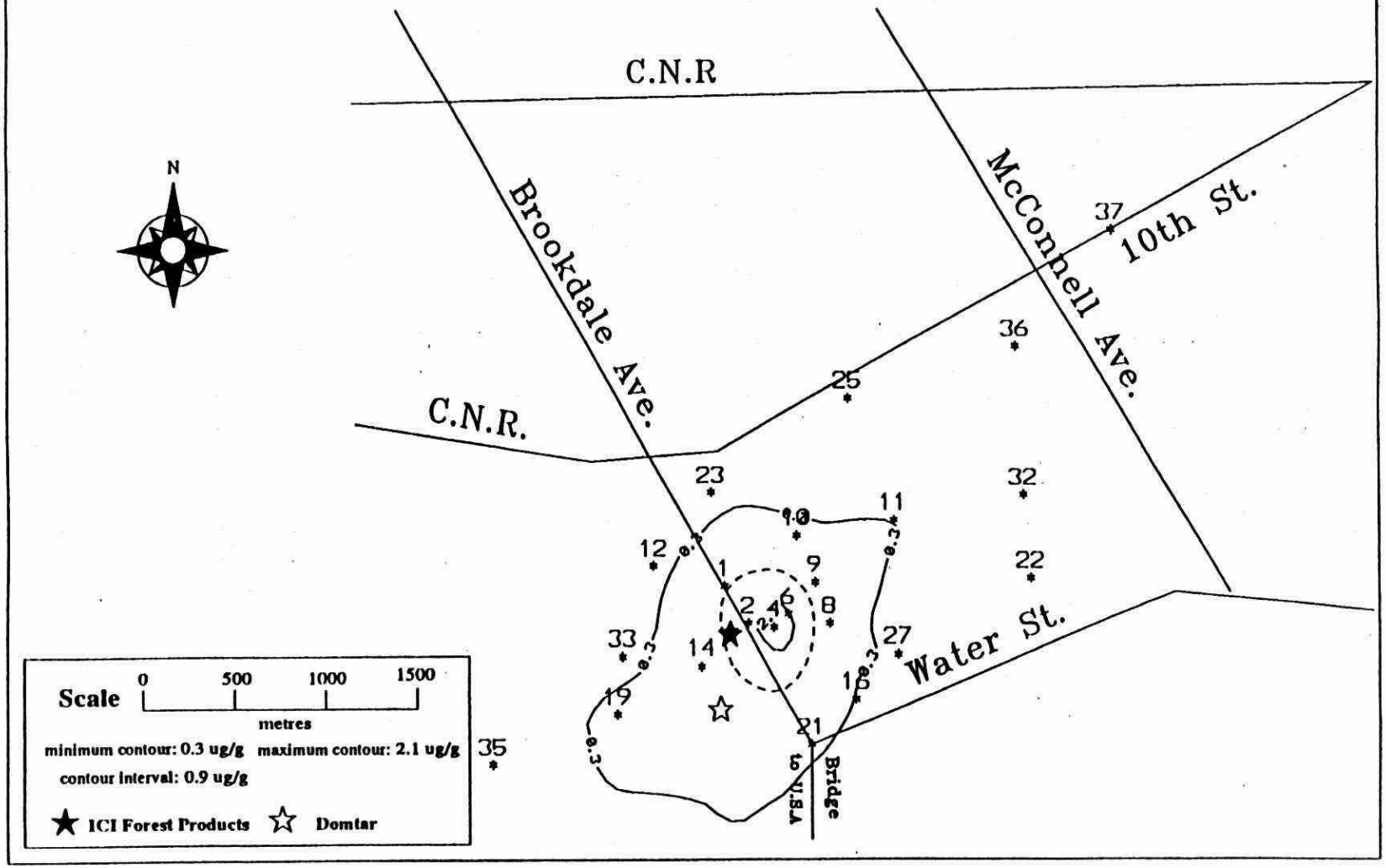


Figure 12: Contour Map of the Mercury Concentration (ug/g, dry wt) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall 1984

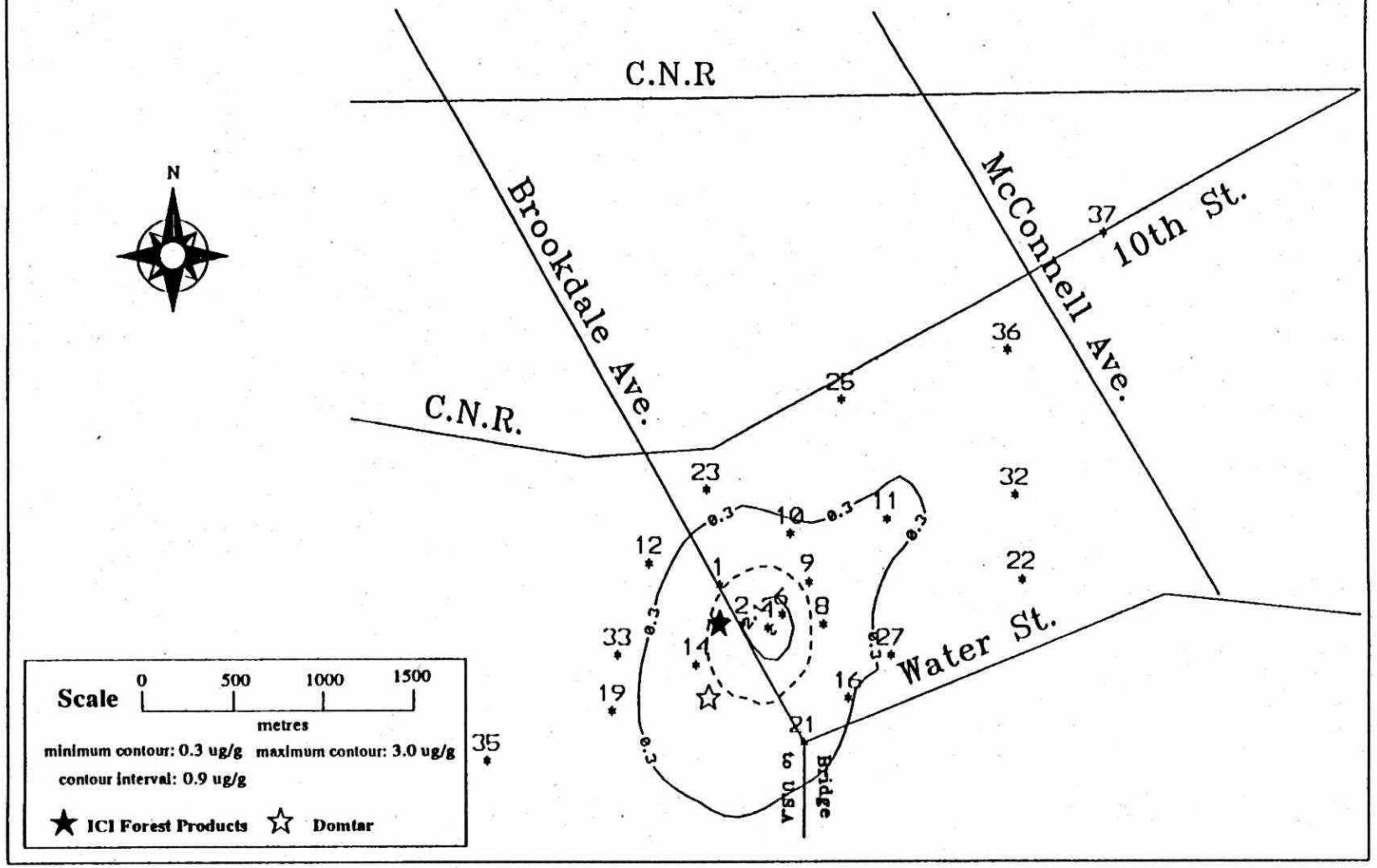


Figure 13: Contour Map of the Mercury Concentration (ug/g, dry wt) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall 1985

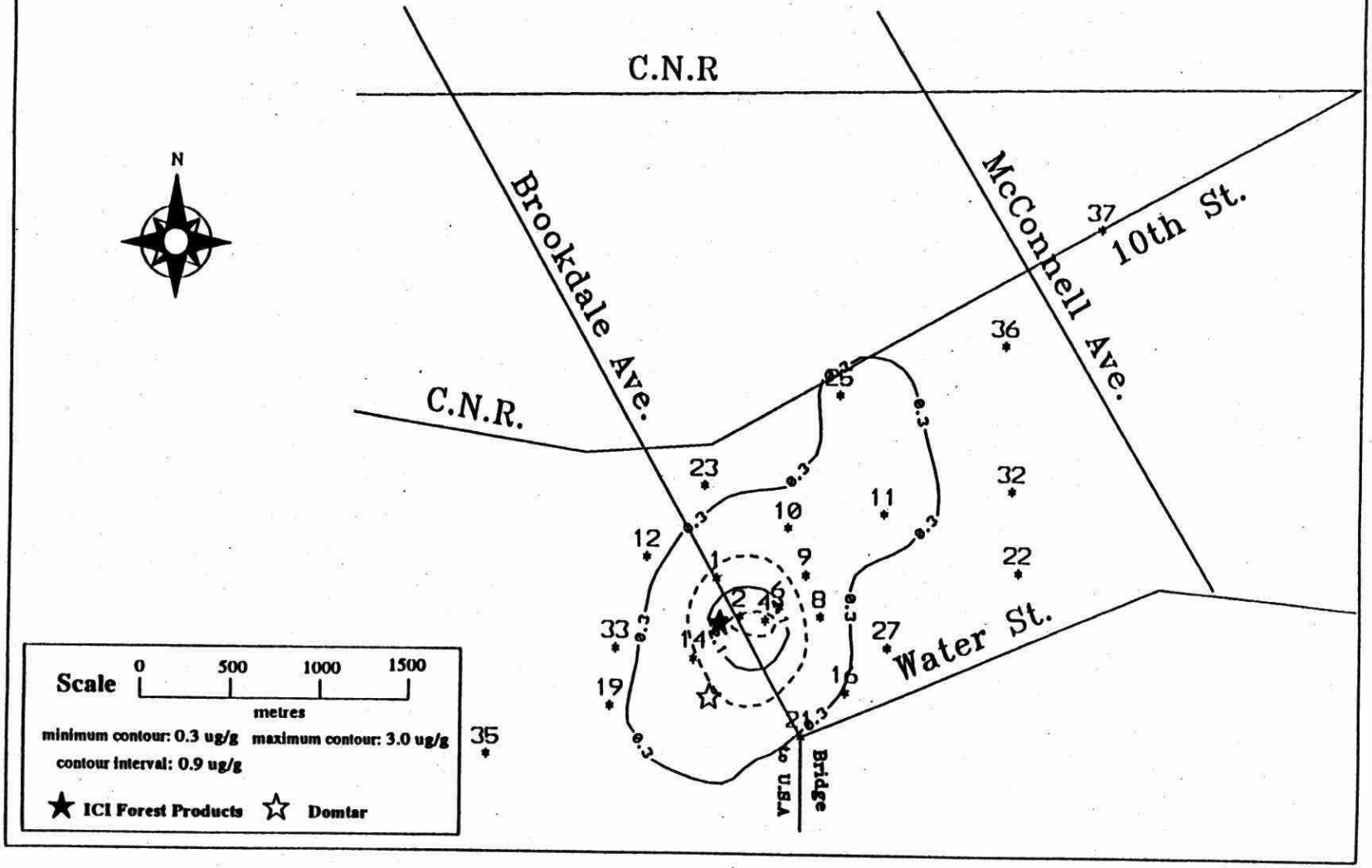


Figure 14: Contour Map of the Mercury Concentration (ug/g, dry wt) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall 1986

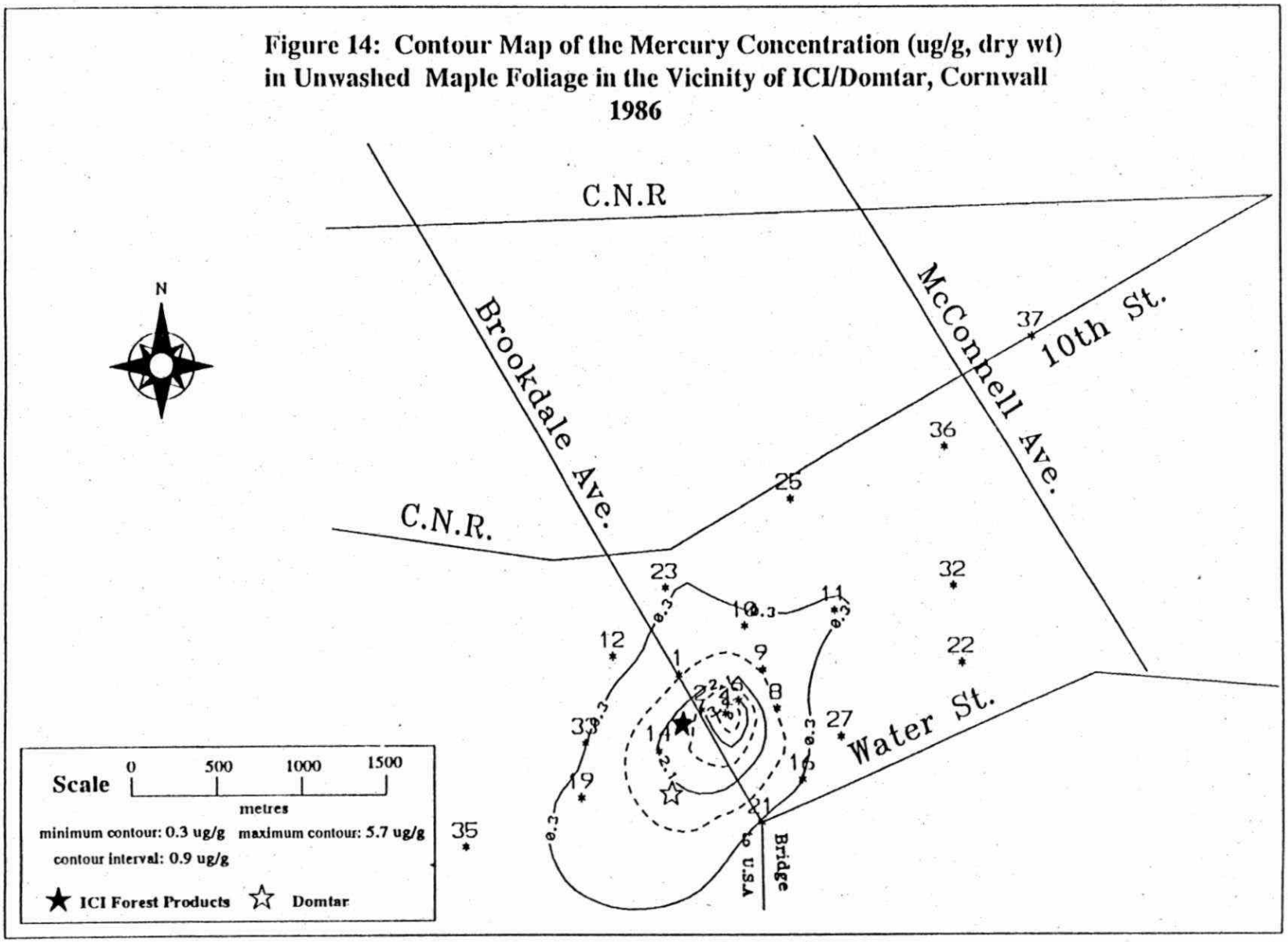


Figure 15: Contour Map of the Mercury Concentration (ug/g, dry wt) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall 1987

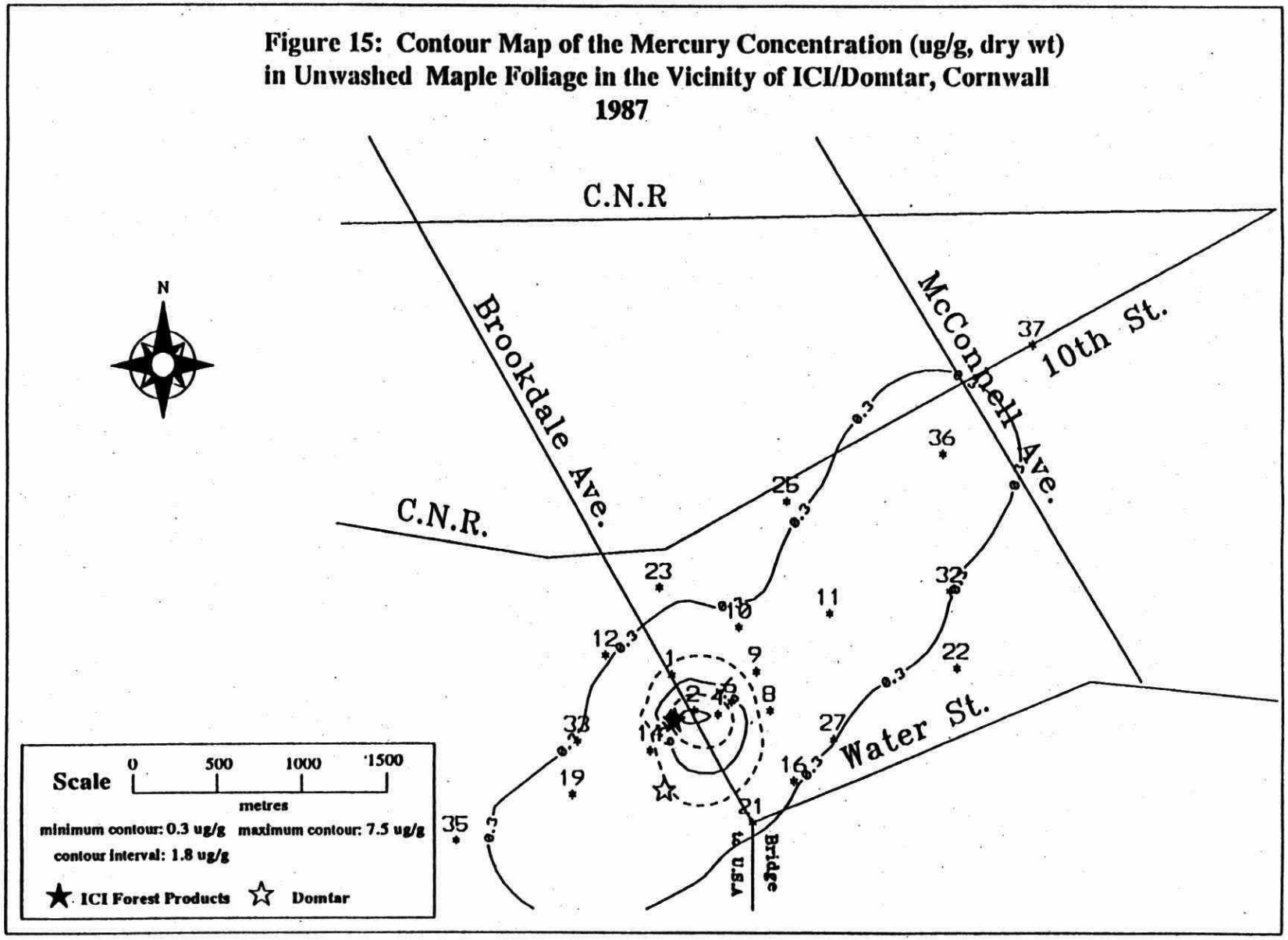


Figure 16: Contour Map of the Mercury Concentration (ug/g, dry wt) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall 1989

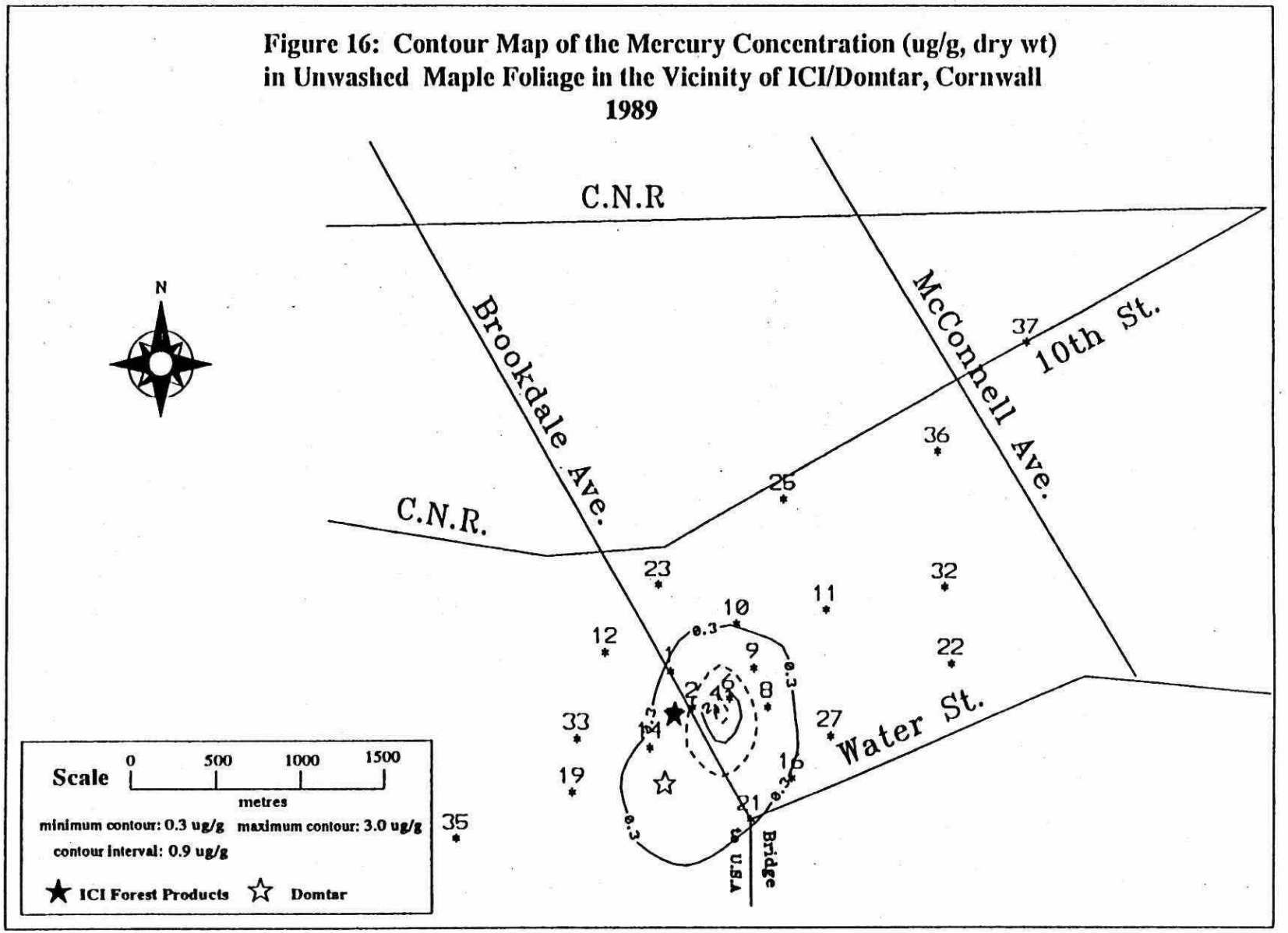


Figure 17: Contour Map of the Mercury Concentration (ug/g, dry wt) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall 1990

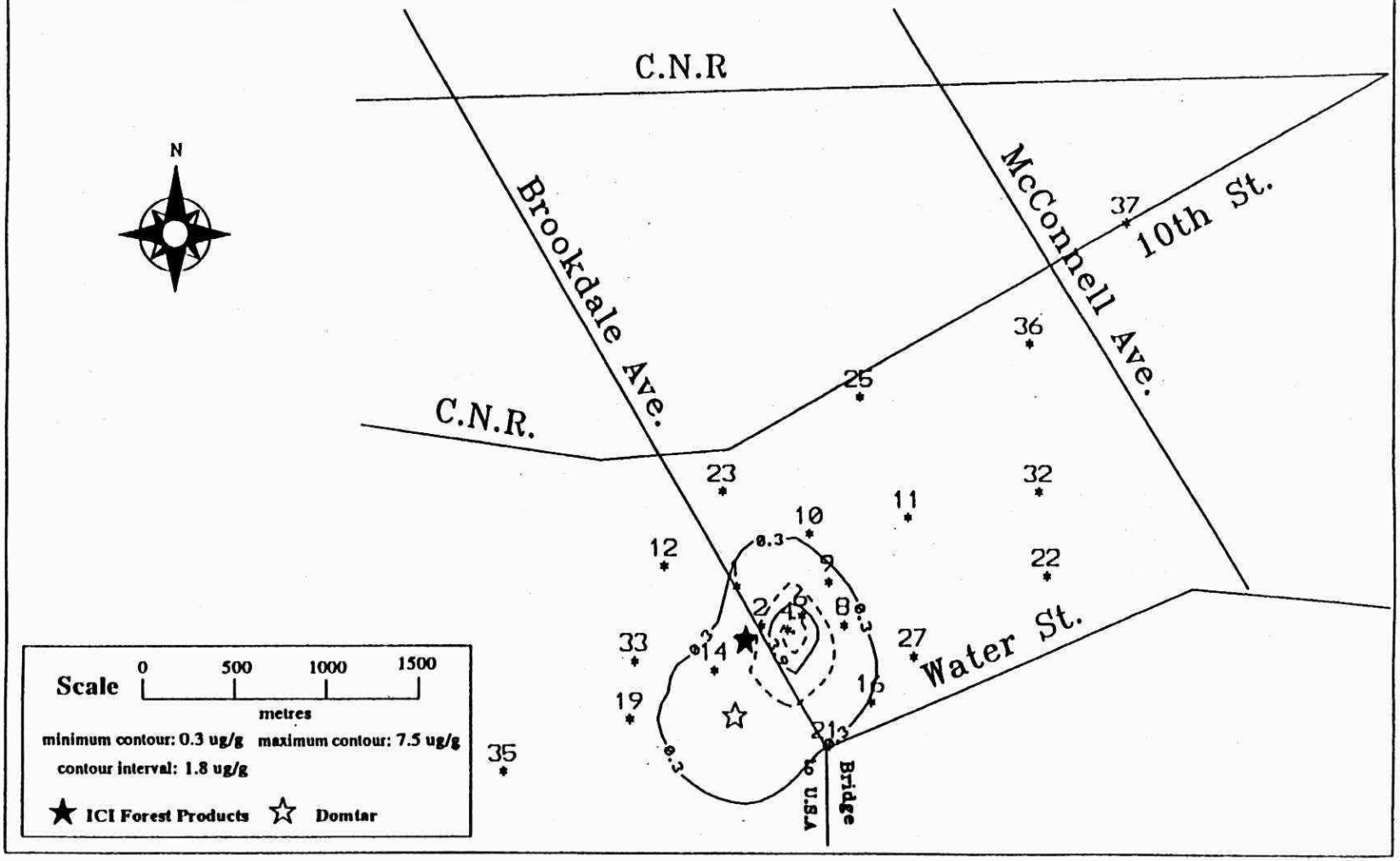


Figure 18: Contour Map of the Mercury Concentration (ug/g, dry wt) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall 1991

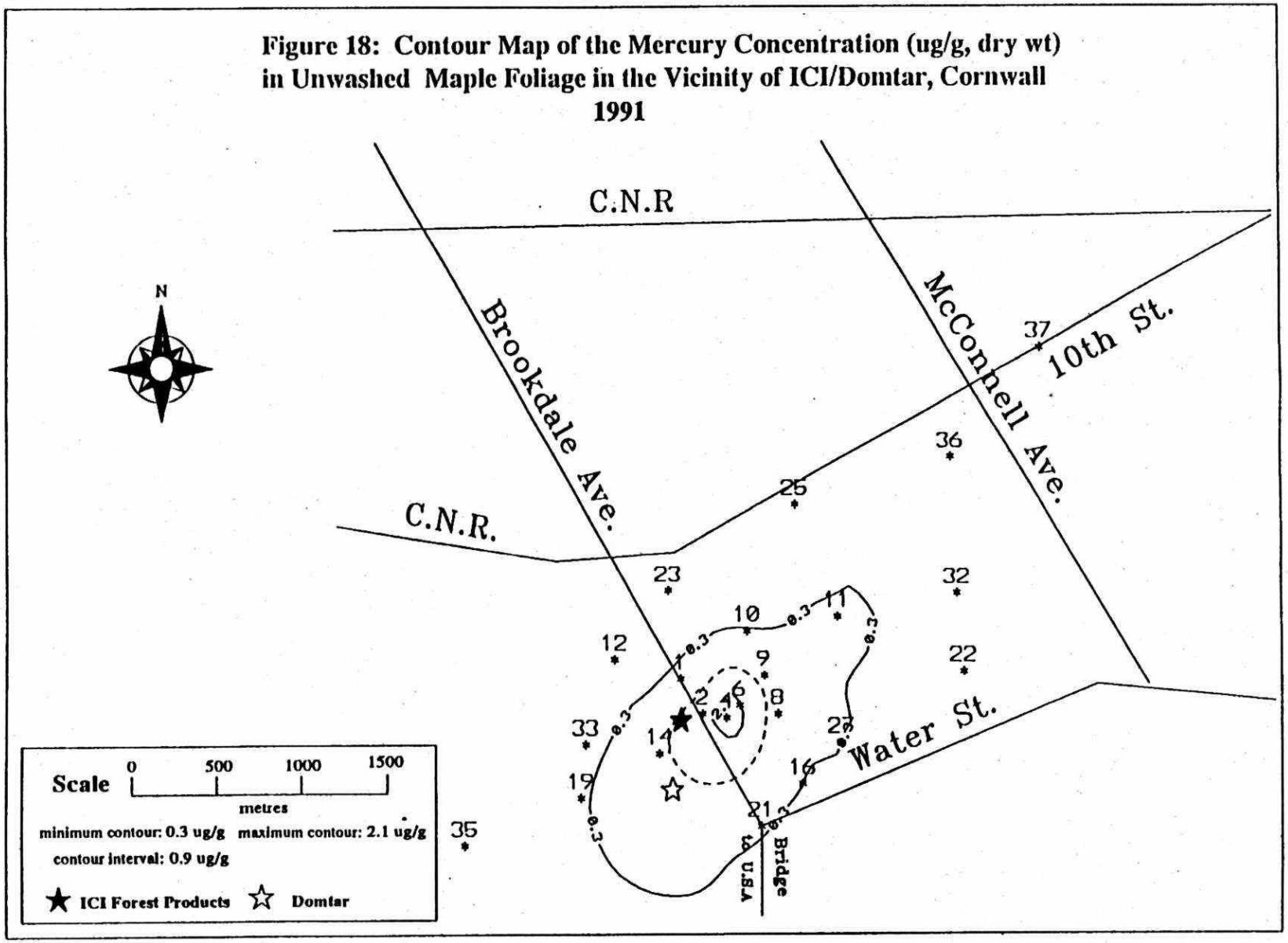


Figure 19: Contour Map of the Mercury Concentration (ug/g, dry wt.) in Soil in the Vicinity of ICI/Domtar, Cornwall - 1976

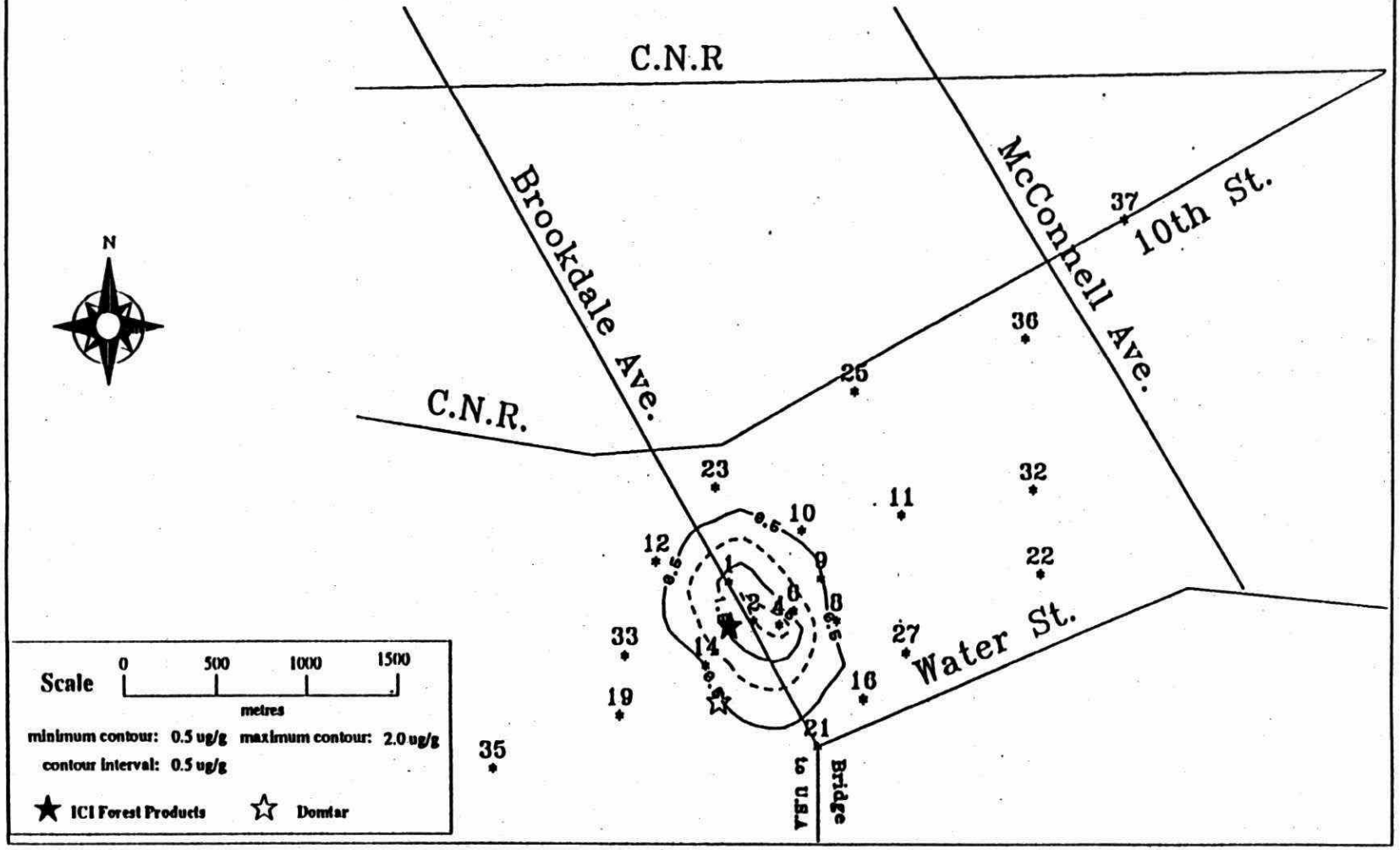


Figure 20: Contour Map of the Mercury Concentration (ug/g, dry wt.) in Soil in the Vicinity of ICI/Domtar, Cornwall - 1978

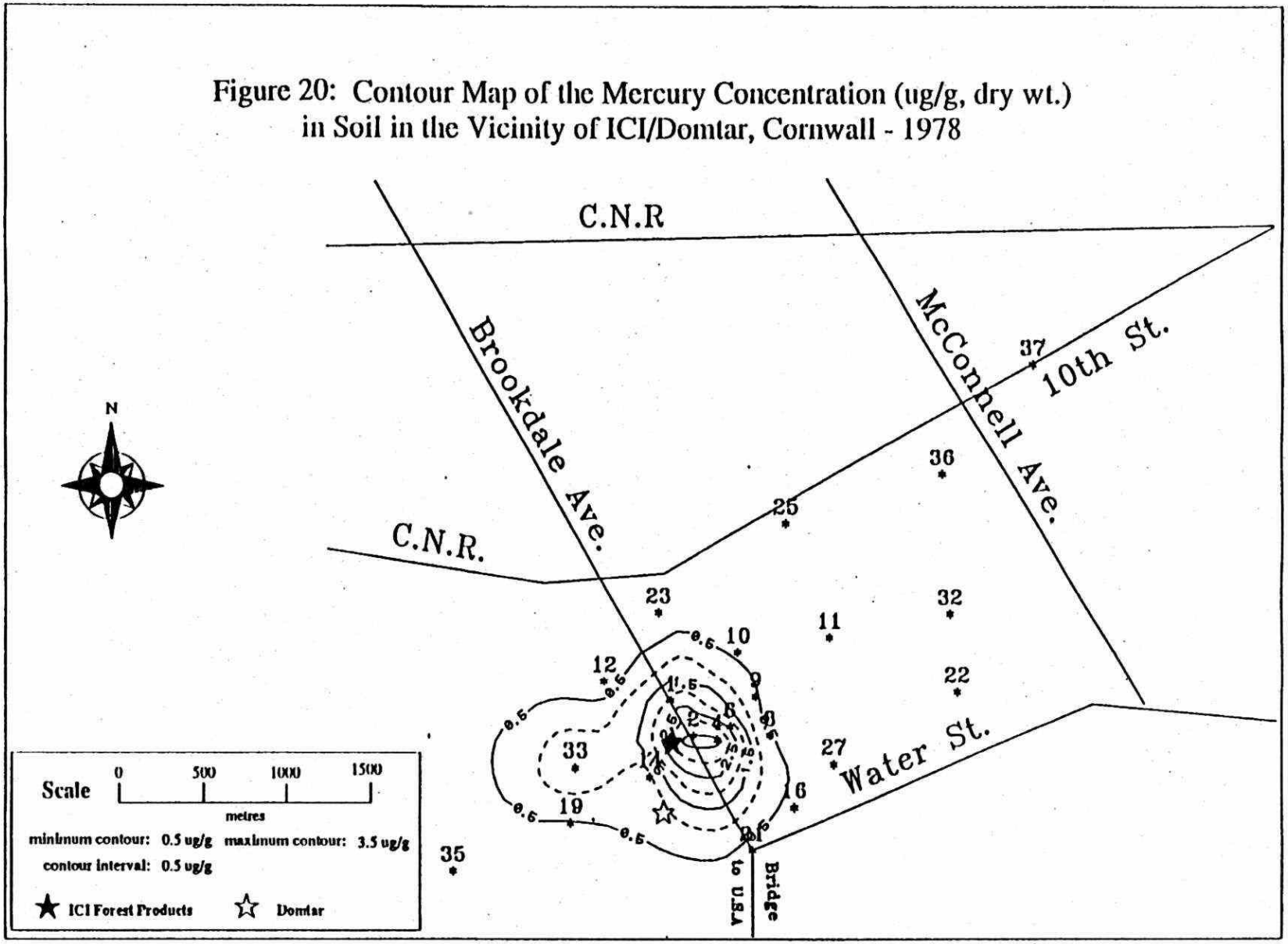


Figure 21: Contour Map of the Mercury Concentration (ug/g, dry wt.) in Soil in the Vicinity of ICI/Domtar, Cornwall - 1985

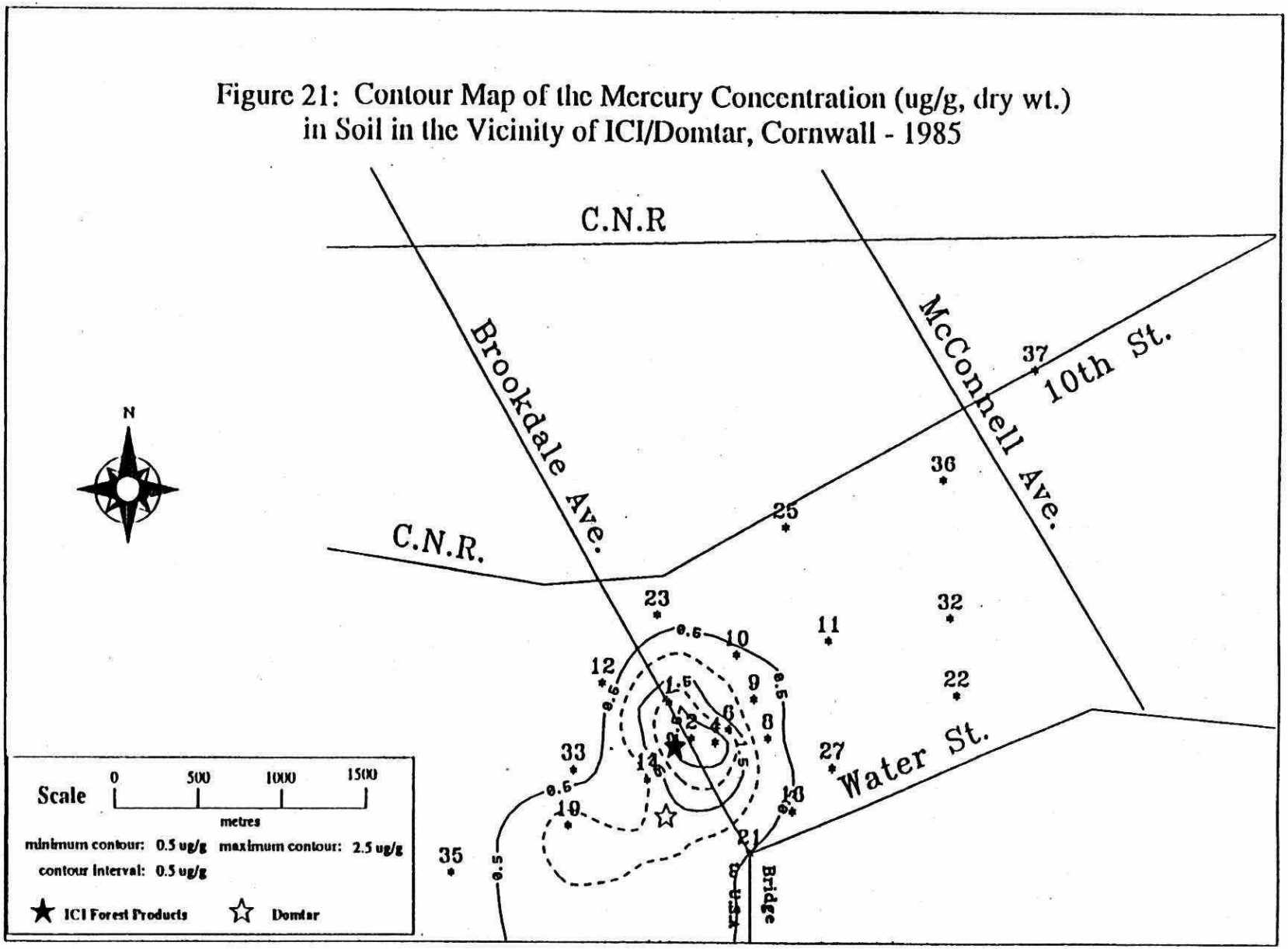


Figure 22: Contour Map of the Mercury Concentration (ug/g, dry wt.) in Soil in the Vicinity of ICI/Domtar, Cornwall - May 1991

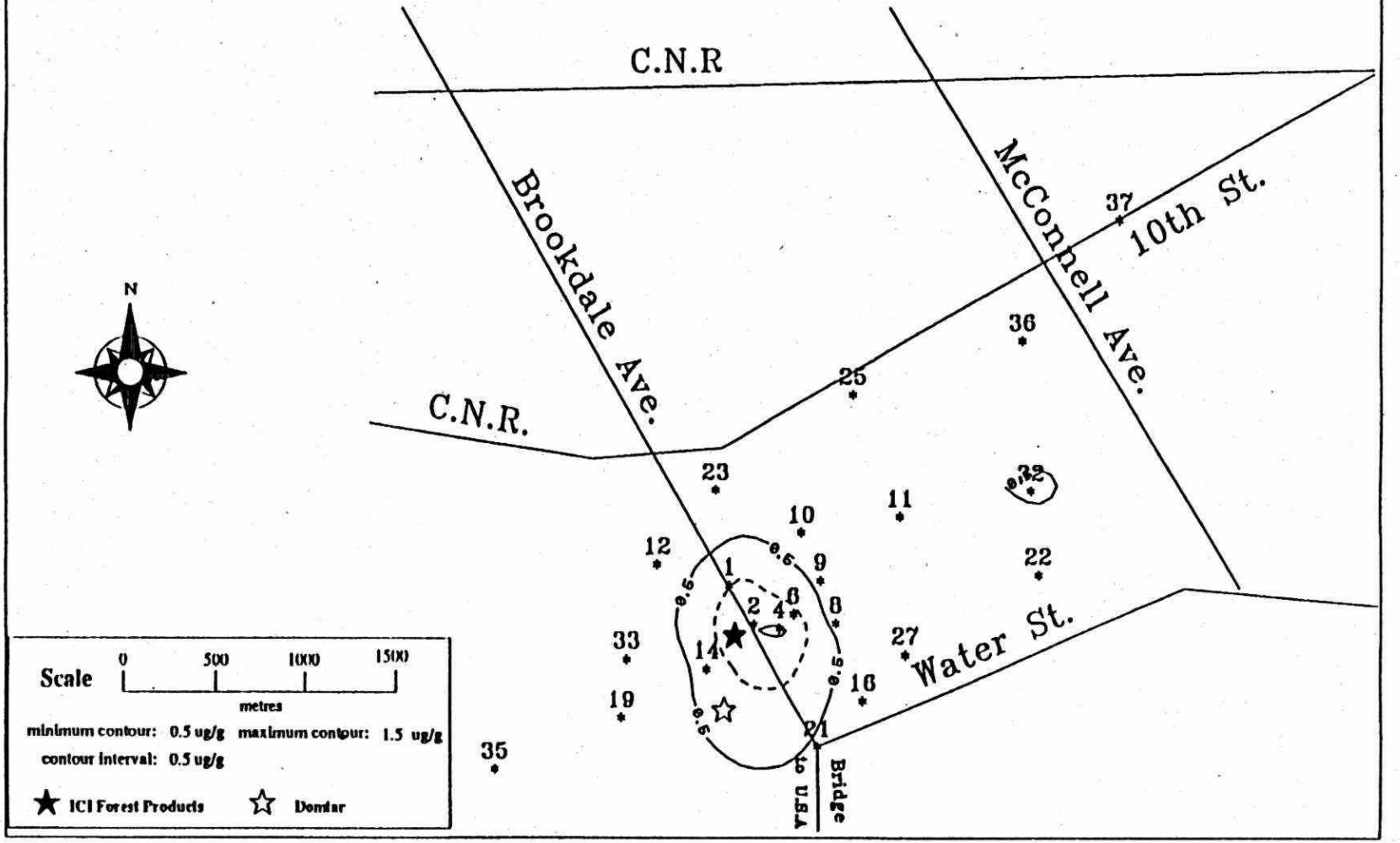
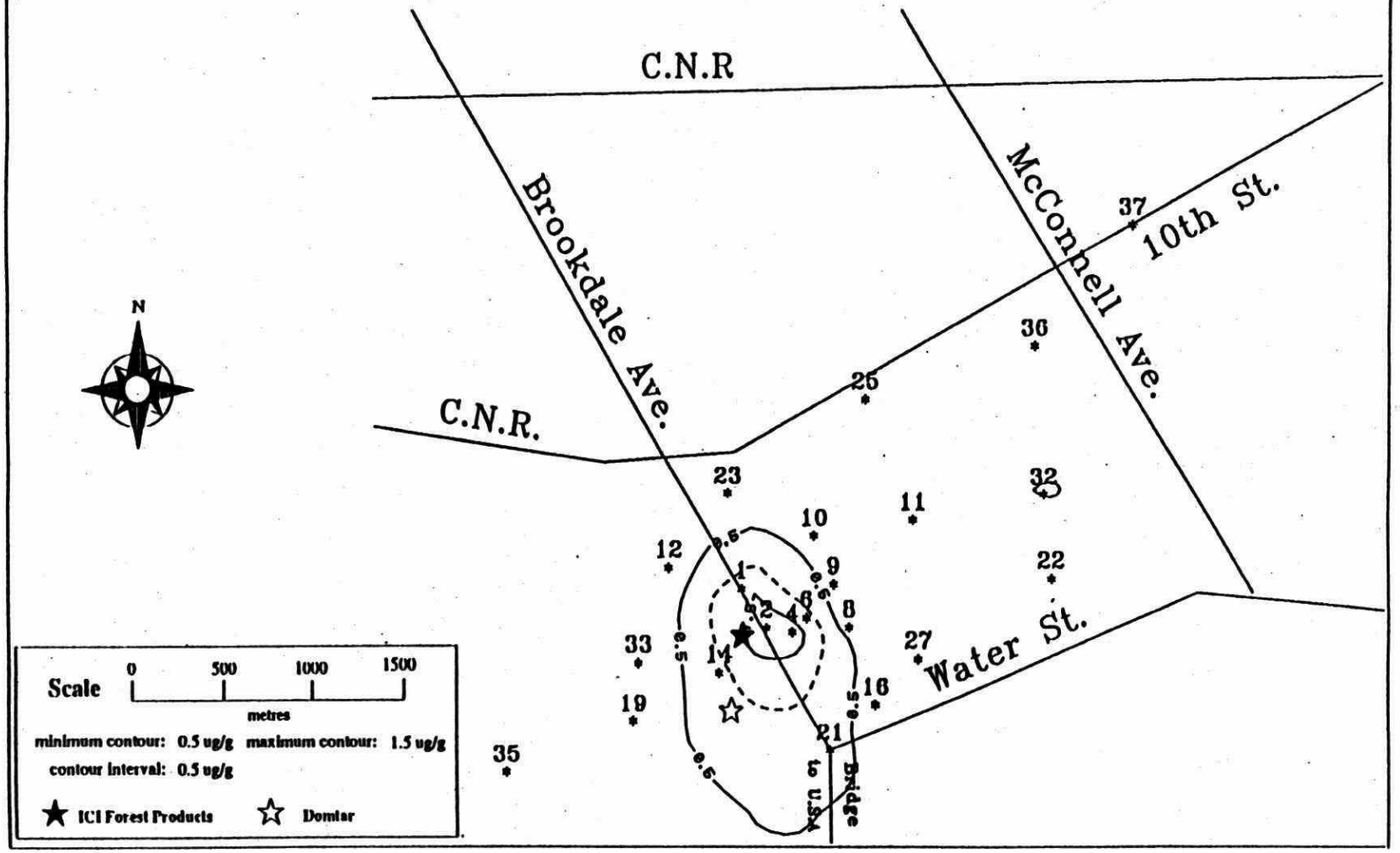


Figure 23: Contour Map of the Mercury Concentration (ug/g, dry wt.) in Soil in the Vicinity of ICI/Domtar, Cornwall - August 1991



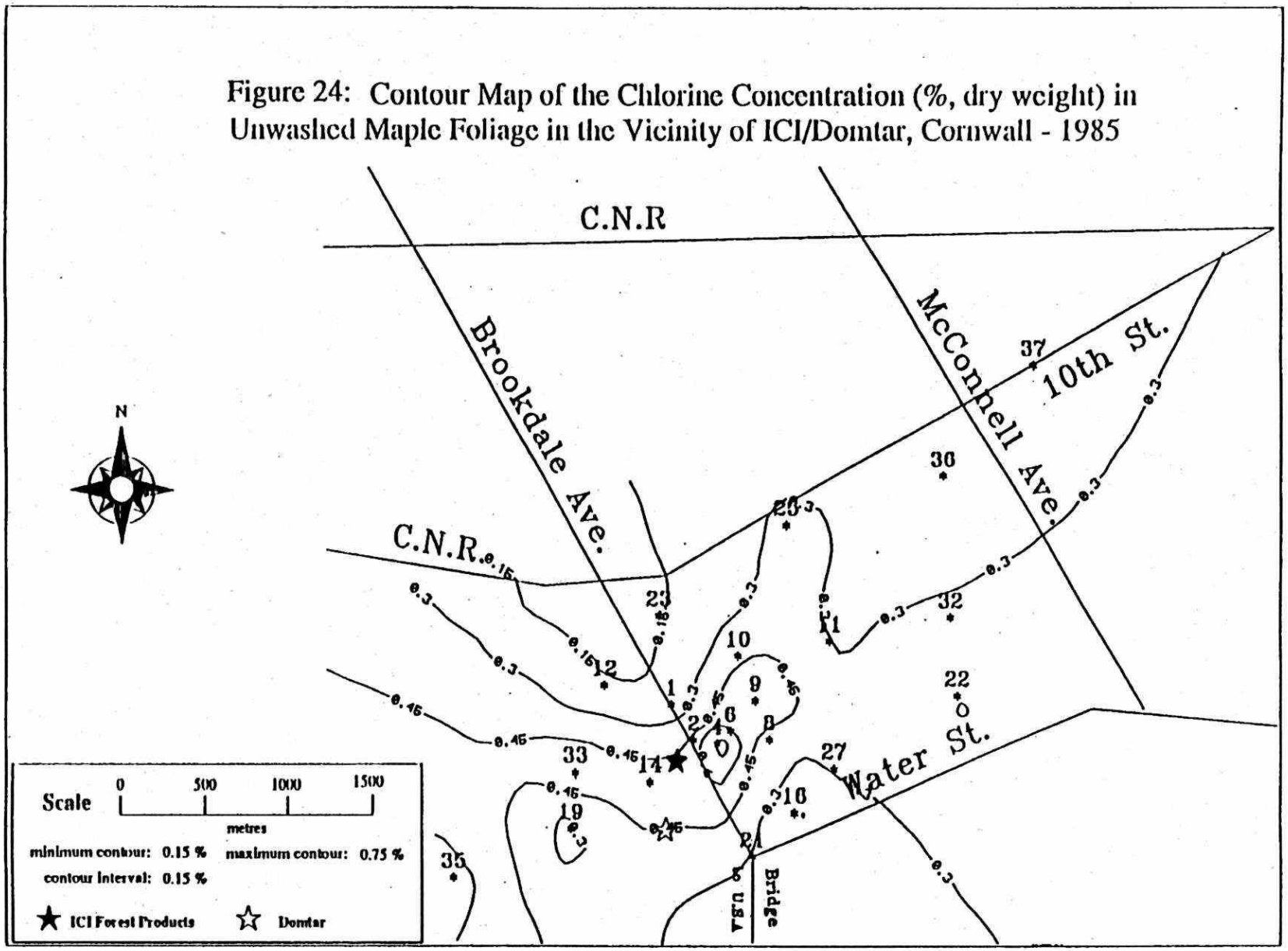


Figure 24: Contour Map of the Chlorine Concentration (%, dry weight) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall - 1985

Figure 25: Contour Map of the Chlorine Concentration (%, dry weight) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall - 1986

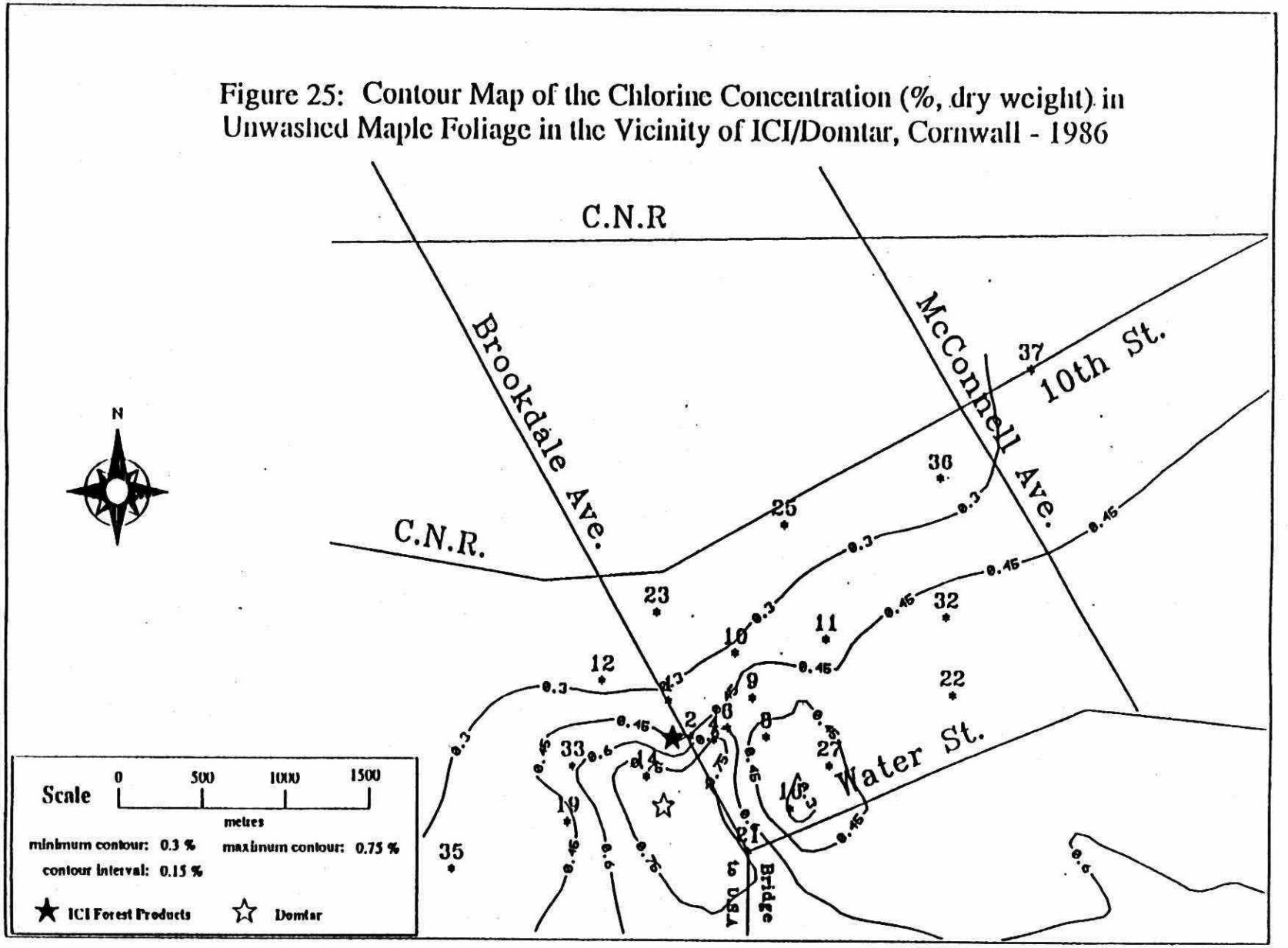


Figure 26: Contour Map of the Chlorine Concentration (%, dry weight) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall - 1987

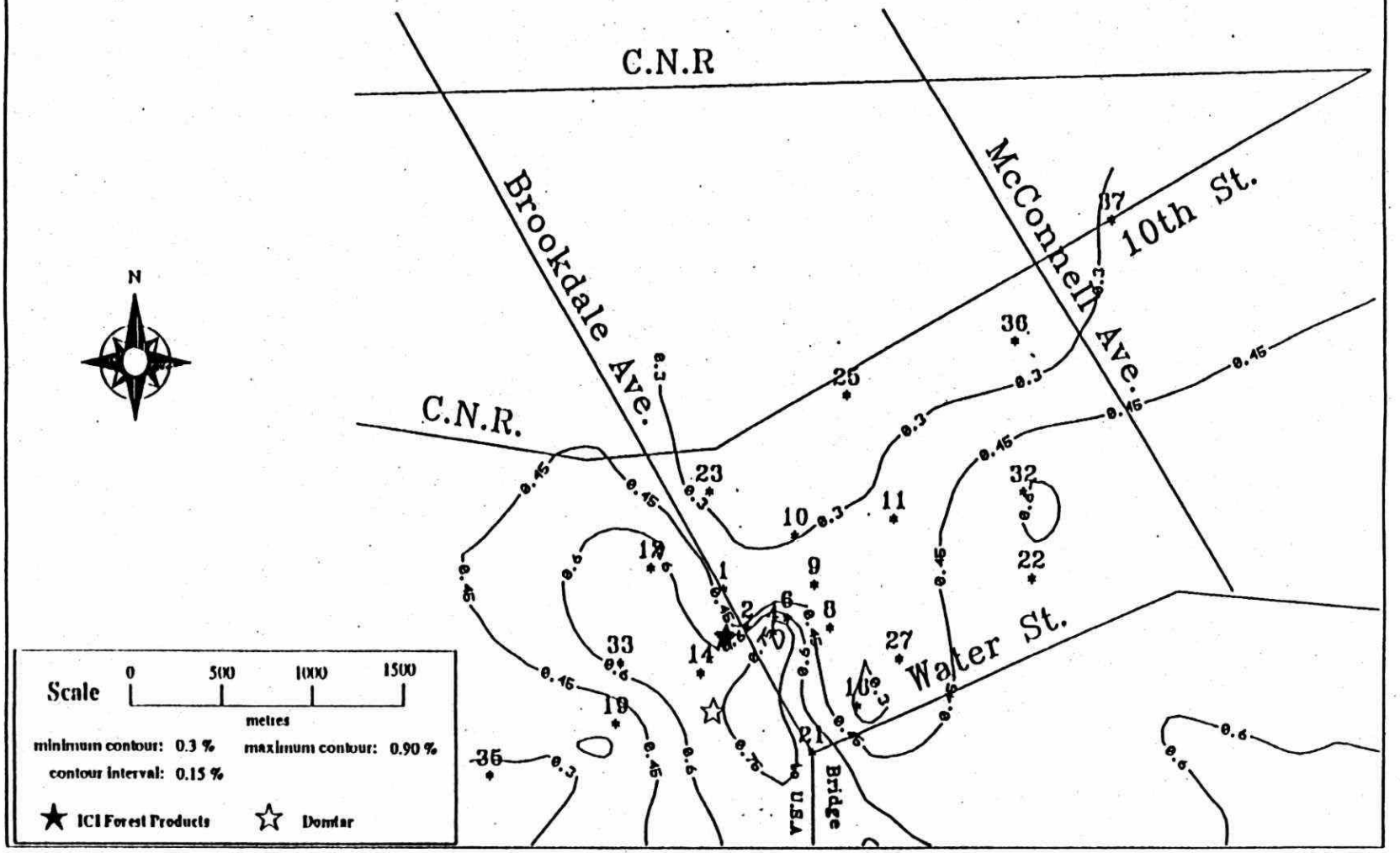


Figure 27: Contour Map of the Chlorine Concentration (%, dry weight) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall - 1989

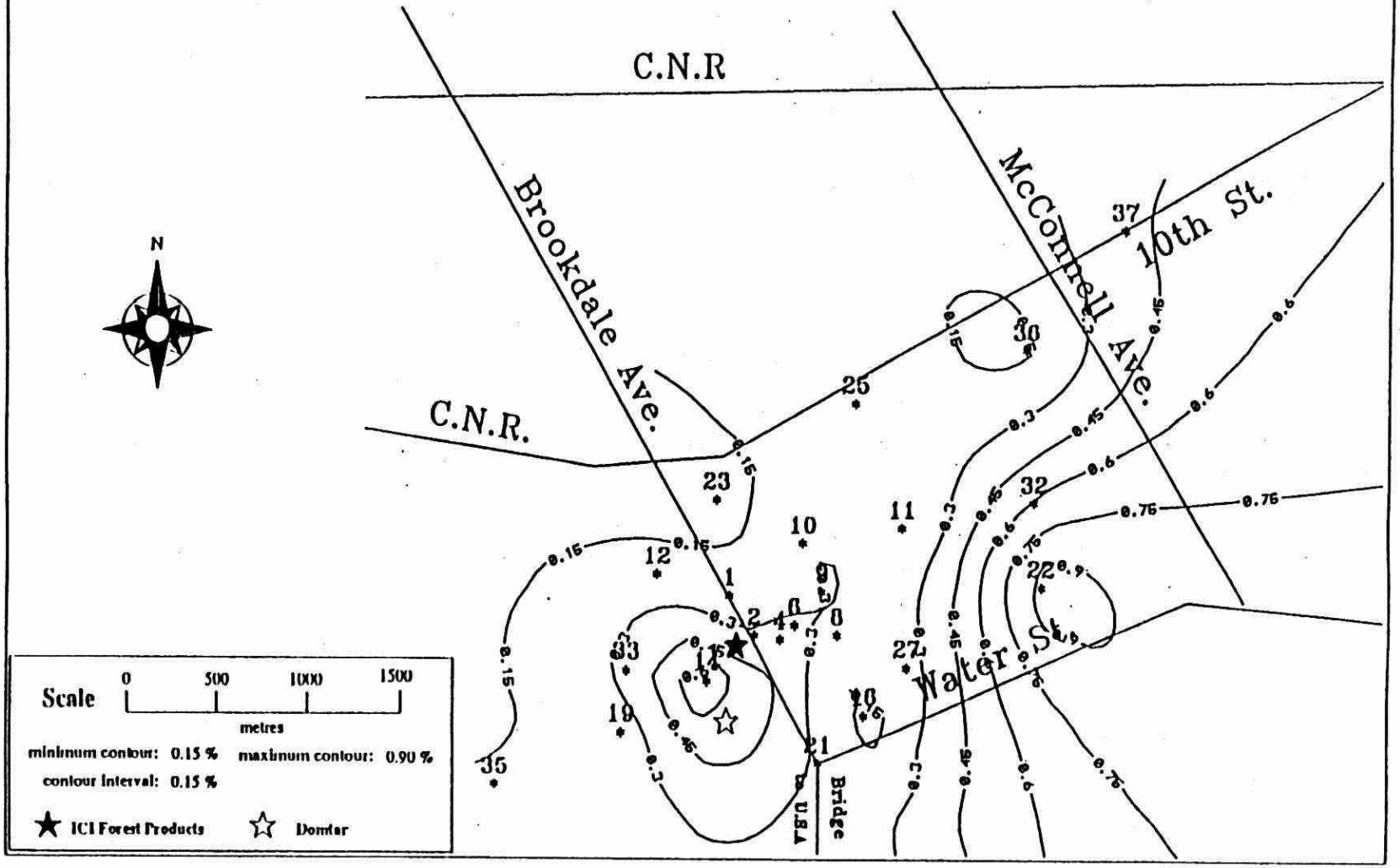


Figure 28: Contour Map of the Chlorine Concentration (%, dry weight) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall - 1990

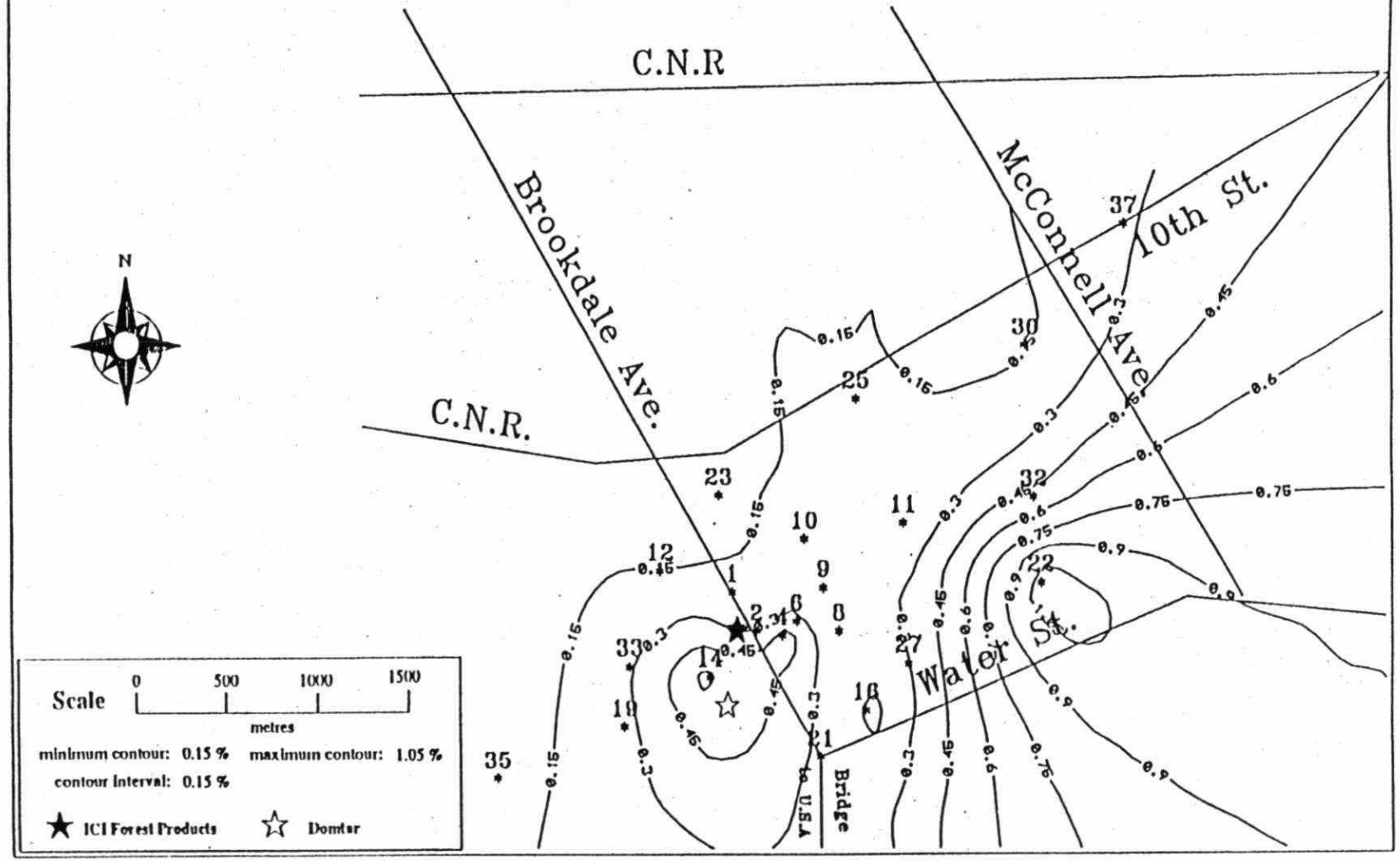
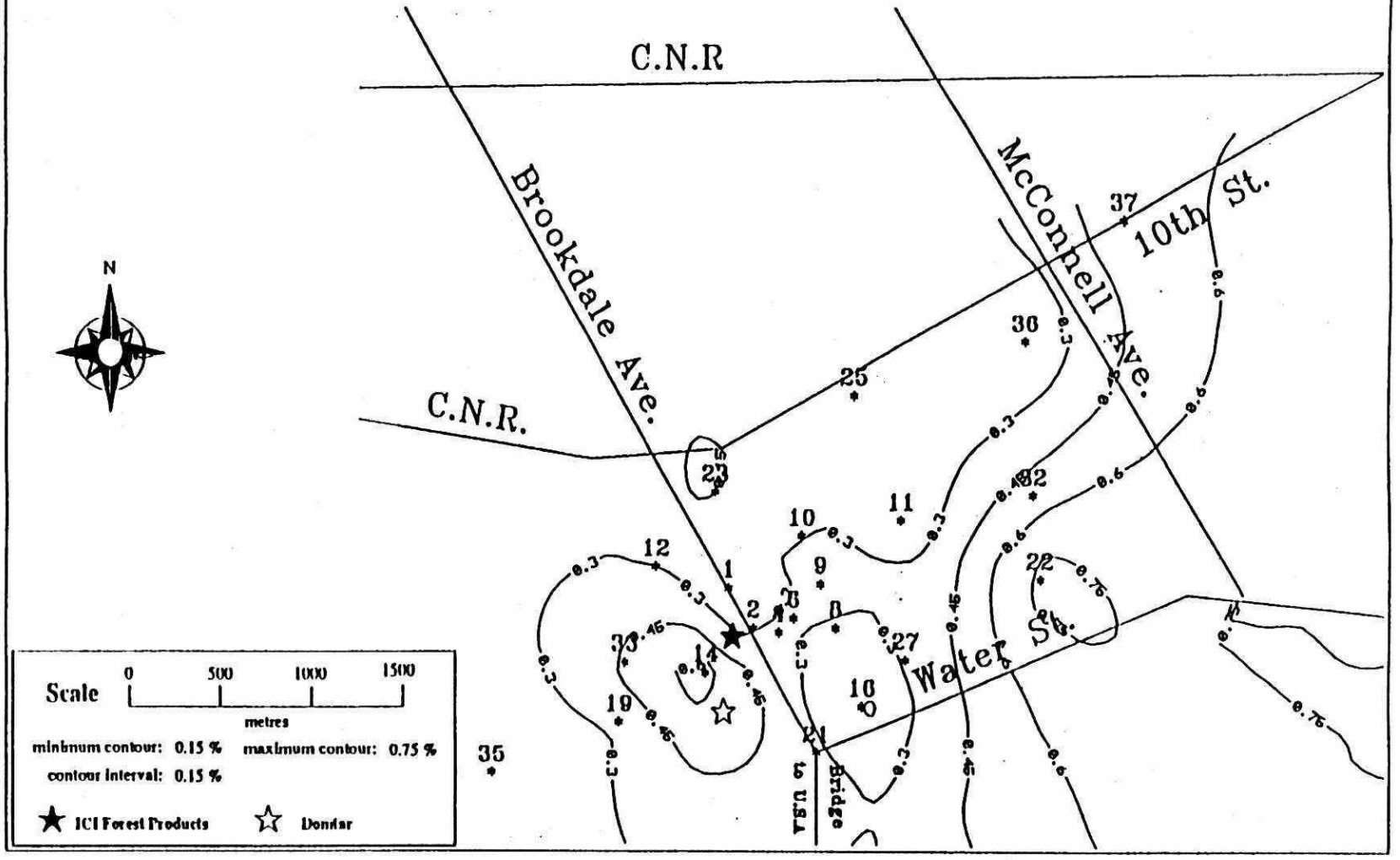


Figure 29: Contour Map of the Chlorine Concentration (%, dry weight) in Unwashed Maple Foliage in the Vicinity of ICI/Domtar, Cornwall - 1991



Appendix A

Derivation and Significance of the MOEE Phytotoxicology
"Upper Limits of Normal" Contaminant Guidelines

The MOEE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a point source of pollution. Urban ULN guidelines are based on samples collected from developed urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures (ref: Ontario Ministry of the Environment 1983, Phytotoxicology Field Investigation Manual). Chemical analyses were conducted by the MOEE Laboratory Services Branch.

The ULN is the arithmetic mean, plus three standard deviations of the mean, of the suitable background data. This represents 99% of the sample population. This means that for every 100 samples which have not been exposed to a point source of pollution, 99 will fall within the ULN.

The ULNs do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULNS are not necessarily toxic to plants, animals, or people. Concentrations that are below the ULNs are not known to be toxic.

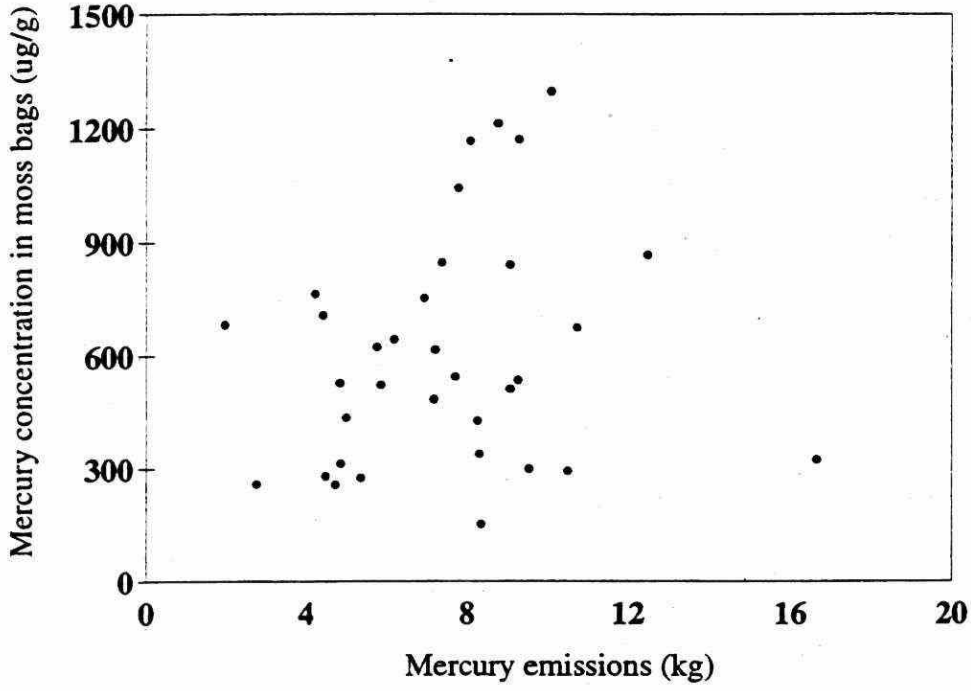
ULNs are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULNs. The MOEE Phytotoxicology ULNs are constantly being reviewed as the background environmental data base is expended. This will result in more ULNs being established and may amend existing ULNs.

Parameter	Soil* (0-5 cm)		Foliage* (unwashed)	
	Urban	Rural	Urban	Rural
Cadmium	4	3	2	1
Chloride	NG	NG	NG	0.15%
Lead	500	150	60	30
Mercury	0.5	0.15	0.3	0.1

* concentrations in ug/g unless stated otherwise
NG - no guideline

Appendix B

Relationship between mercury concentration in moss bags located on the roof of ICI Forest Products cell room and mercury emissions



Regression Analysis

Multple R: 0.176 Squared Multiple R: 0.031
Standard Error of Estimate: 2.9011

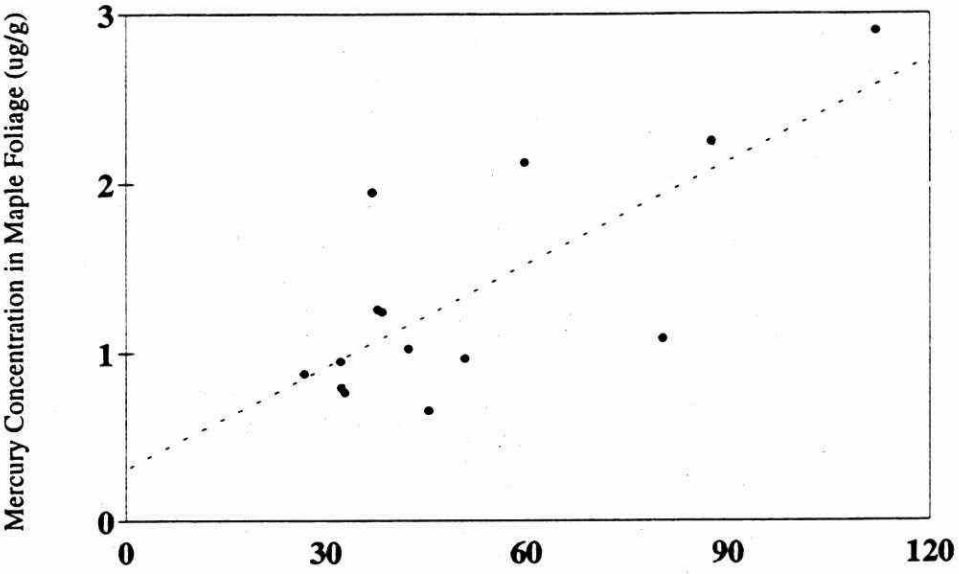
Variable	Coefficient	Std Error	Std Coef	T	P (2 tail)
Constant	6.4367	1.1180	0.00	.7572	0.22E -5
Mosshg	0.0017	0.0016	0.1760	1.0112	0.3195

Analysis of Variance

Source	Sum of Squares	DF	Mean Square	F-Ratio	P
Regression	8.6068	1	8.6068	1.0226	0.3195
Residual	269.3257	32	8.4164		

Appendix C

Relationship between mercury concentration in maple foliage and mercury emissions from ICI Forest Products (data is from 1976 to 1991, excluding 1982 and 1988)



Regression Analysis

Multple R: 0.750 Squared Multiple R: 0.563
Standard Error of Estimate: 0.4693

Variable	Coefficient	Std Error	Std Coef	T	P (2 tail)
Constant	0.3049	0.2927	0.00	1.0415	0.3182
hglvs	0.0203	0.0052	0.7501	3.9289	0.002

Analysis of Variance

Source	Sum of Squares	DF	Mean Square	F-Ratio	P
Regression	3.3998	1	3.3998	15.4361	0.002
Residual	2.6430	12	0.2202		

Appendix D

The T statistics and probability values from paired T tests for the years 1976,1978, 1985 and 1991 for mercury in surface soil (0-5 cm) collected in the vicinity of ICI Forest Products, Cornwall

	1978	1985	May 1991	August 1991
1976	T=-1.5264	T=-2.6951	T=-1.0824	T=-0.9864
	P=0.1453	**P=0.0153**	P=0.2942	P=0.3377
1978		T=-1.0645	T=0.9436	T=1.0749
		P=0.2992	P=0.3561	P=0.2946
1985			T=2.6814	T=2.8754
			P=0.014	**P=0.0091**
May 1991				T=-0.6615
				P=0.5155

Appendix E

The T statistics and probability values from paired T tests for the years 1985, 1986, 1987, 1990 and 1991 for chloride in maple foliage collected in the vicinity of ICI Forest Products and Domtar

	1986	1987	1989	1990	1991
1985	T=-1.6841	T=-1.4123	T=2.7237	T=2.7953	T=1.2406
	P=0.1070	P=0.1725	**P=0.0127**	**P=0.0108**	P=0.2284
1986		T=-0.1898	T=4.6160	T=5.8469	T=3.3819
		P=0.8513	**P=0.0001**	**P=0.00008**	**P=0.0028**
1987			T=4.6935	T=5.033	T=3.3054
			P=0.0001	**P=0.0005**	**P=0.0034**
1989				T=0.1857	T=-3.255
				P=0.8544	**P=.0038**
1990					T=-3.1346
					P=0.005

P values which are in bold indicate that the means for the two year tested are significantly different
All data in both Appendix D and E are log transformed